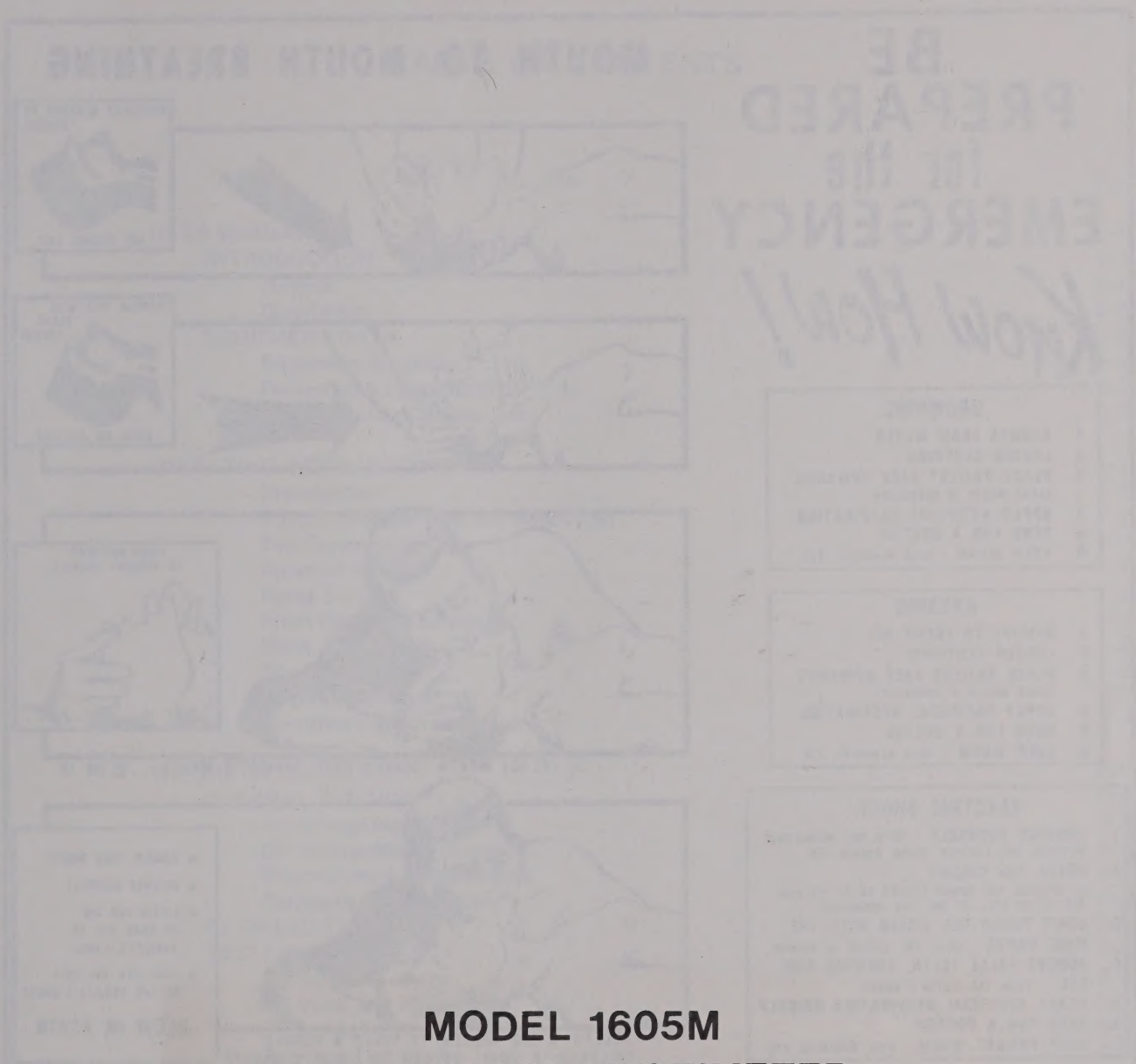
HICKOK

MODEL 1605M
SOLID STATE MULTIMETER

INSTRUCTION MANUAL

111 ASOC

HICKOK ELECTRICAL INSTRUMENT COMPANY
10514 Dupont Avenue • Cleveland, Ohio 44108 • Phone 216-541-8060



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The Hickok Electrical Instrument Company

10514 DUPONT AVENUE • CLEVELAND, OHIO 44108 • (216) 541-8060 • TWX: 810-421-8286

BE PREPARED for the EMERGENCY *Know How!*

DROWNING

1. REMOVE FROM WATER
2. LOOSEN CLOTHING
3. PLACE PATIENT FACE UPWARDS
   CLEAR MOUTH IF NECESSARY
4. APPLY ARTIFICIAL RESPIRATION
5. SEND FOR A DOCTOR
6. KEEP WARM - WITH BLANKETS, ETC.

GASSING

1. REMOVE TO FRESH AIR
2. LOOSEN CLOTHING
3. PLACE PATIENT FACE UPWARDS
   CLEAR MOUTH IF NECESSARY
4. APPLY ARTIFICIAL RESPIRATION
5. SEND FOR A DOCTOR
6. KEEP WARM - WITH BLANKETS, ETC.

ELECTRIC SHOCK

1. PROTECT YOURSELF - WITH DRY INSULATING MATERIAL DRY LEATHER, WOOD, RUBBER ETC.
2. BREAK THE CIRCUIT - BY OPENING THE POWER SWITCH OR BY PULLING THE VICTIM FREE OF THE LINE CONDUCTOR
3. DON'T TOUCH THE VICTIM WITH THE BARE HANDS - UNTIL THE CIRCUIT IS BROKEN
4. REMOVE FALSE TEETH, CHEWING GUM, ETC. - FROM THE VICTIM'S MOUTH
5. START ARTIFICIAL RESPIRATION QUICKLY
6. SEND FOR A DOCTOR
7. KEEP PATIENT WARM - WITH BLANKETS, ETC.

MOUTH TO MOUTH BREATHING

. . . . PLACE MOUTH TIGHTLY OVER SUBJECT'S MOUTH . . . BLOW IN

- REMOVE YOUR MOUTH
- RELEASE NOSTRILS
- LISTEN FOR AIR TO COME OUT OF SUBJECT'S LUNGS
- LOOK FOR THE FALL OF THE SUBJECT'S CHEST

BLOW IN AGAIN

ADULTS: A BIG BREATH, 12 TIMES A MINUTE
CHILDREN: A SMALL BREATH, 16 TIMES A MINUTE

AIR PASSAGES MUST BE KEPT OPEN AT ALL TIMES

IF AIR PASSAGES ARE NOT OPEN THERE WILL BE
NO SOUND OF ESCAPING AIR
NO RISE OR FALL OF THE CHEST
RESISTANCE WHEN BLOWING INTO THE SUBJECT'S MOUTH

THEREFORE CHECK NECK AND HEAD POSITION AGAIN
CHECK MOUTH AND THROAT FOR FOREIGN SUBSTANCES.

AIR MAY GO TO STOMACH WHICH WILL DISTEND IT.
TAKE HAND FROM CHIN, PRESSING STOMACH GENTLY, FORCING AIR OUT.

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PART 0
DATA SUMMARY

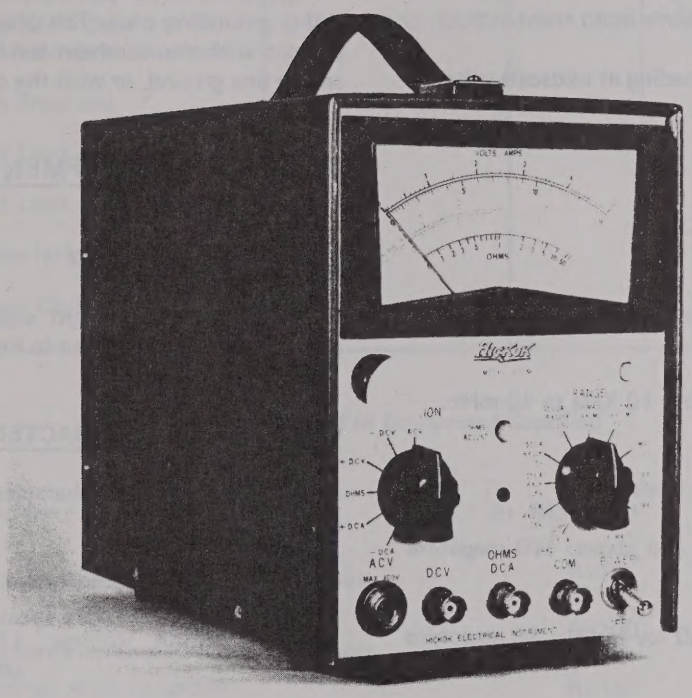


Fig. 0-1 General Purpose Electronic Multimeter (Hickok Model 1605M)

INTRODUCTION

PURPOSE

0-1 (a) The General Purpose Electronic Multimeter, (Hickok Model 1605M), is a portable multimeter, manufactured by the Hickok Electrical Instrument Company, Cleveland, Ohio. It provides an accurate means of measuring a wide range of ac voltage, dc voltage, current and resistance with extremely low-power absorption from the circuit under test.

(b) When used as a dc voltmeter, the meter is capable of indicating full scale for ranges between ±15 millivolts and ±1,500 volts. As a dc ammeter, indications may be obtained for ranges between ±1.5 μa and ±150 ma. Also special ranges of ±1.5, ±5 and ±15 nano amps may be monitored using the dc voltmeter probe. Resistance measurements can be made under 1 ohm and over 500 megohms. By means of a special rectifying probe, ac voltage between 0.5 and 300 volts (rms) can be measured, over a wide range of frequencies from 20 Hz to 700 mHz.

(c) The electronic voltmeter is a self-contained portable multimeter, ruggedly designed with solid-state circuitry for general field servicing applications. It is particularly suited to mobile ground facilities.

(d) Frequency:

Range for ac measurements 20 Hz to 700 mHz.

Response: Flat within ±1 db from 20 Hz to 700 mHz.

(e) Accuracy of Calibration:

AC voltmeter: On any voltage range, ±3% of full scale value at any point on the scale for sinusoidal ac voltages from 100 Hz to 100 mHz, and within one db from 20 Hz to 700 mHz for sinusoidal voltages.

NOTE

The instrument is positive peak responding and is calibrated to indicate the rms value of a sine wave.

DC voltmeter: On any voltage range, ±2% of full scale value at any point on the scale.

DC ammeter: On any of the 11 current ranges, ±3% of full scale value at any point on the scale. For special ranges: ±5% with 10 megohms input resistance.

Ohmmeter: ±5% of reading at midscale value.

(f) Input Impedance

AC voltmeter:
Input Capacity: 1.5 pf

Input Resistance:
For frequencies up to 10 KHz:
10 megohms

For frequencies from 10 KHa to 10 mHz:
1 megohm

DC voltmeter: Input Resistance:

On 500 mv range and above: 100 megohms ±1%

On 15, 50 and 150 mv ranges: 10 megohms ±1%

DC ammeter: Input Resistance:

9K ohms on 1.5 μa scale, decreasing to 0.3 ohms on the 150 ma scale.

DESCRIPTION

0-2 (a) The multimeter consists of a front panel, a deep rectangular chassis and a rear panel, and is enclosed in a sheet metal case.

(b) The front panel contains a D'Arsonval movement milliammeter, suitably calibrated for the various functions to be measured. All switches and adjustments required during operation of the multimeter, and connectors for the test leads, are located on the front panel.

(c) The chassis supports two printed circuit boards. The top board incorporates adjustable calibration potentiometers. The second printed circuit board contains the amplifier circuitry and power supply. The power transformer is located inside the rectangular chassis and is accessible from the bottom.

(d) Connections from the printed circuit boards to the switches (which incorporate the input divider resistors) and to the front panel controls are made via a cable harness. The wires are soldered to the printed circuit boards for reliability but can be removed easily for maintenance or trouble shooting purposes.

(e) On the rear panel is the line fuse, a voltage selector and a grounding plug. This plug enables the instrument to be used with the common test lead grounded to the chassis and ac line ground, or with the common test lead floating.

EQUIPMENT DATA

EQUIPMENT SUPPLIED

0-3 Details of equipment supplied, including test leads, prods and probes are given in Fig. 0-2.

PERFORMANCE CHARACTERISTICS

0-4 The performance characteristics of the Multimeter are as follows:

(a) Power Requirements:

Input Voltage: 115/230 volts ±10%, single phase

Frequency: 50 to 400 Hz

Power Consumption: 8 watts (including ac probe)

(b) DC Voltage Ranges:

0 to 0.015 volts
0 to 0.050 volts
0 to 0.150 volts
0 to 0.5 volts
0 to 1.5 volts
0 to 5 volts
0 to 15 volts
0 to 50 volts
0 to 150 volts
0 to 500 volts
0 to 1500 volts

(c) AC Voltage Ranges:

0 to 0.5 volts
0 to 1.5 volts
0 to 5 volts
0 to 15 volts
0 to 50 volts
0 to 150 volts
0 to 300 volts

Qty Per Equipment	Name of Item and AN Designation	National Stock Number	Overall Dimension (in.)			Net Weight lb.
			Height	Width	Depth	
1	General Purpose Electronic Multimeter	6625-00-168-0503	7-1/2	5-1/2	9-1/2	10
1	Test Prod (dc)					
1	Test Lead - (ohms-ma)					
1	Test Lead - (common)					
1	Probe (ac)					
1	Power Cord					

Fig. 0-2 List of Equipment Supplied

(d) DC Amperage Ranges + or -

0 to 1.5 nanoamps measured on 15 millivolt dc range with dcv probe
0 to 5 nanoamps measured on 50 millivolt dc range with dcv probe
0 to 15 nanoamps measured on 150 millivolt dc range with dcv probe
0 to 1.5 microamps
0 to 5 microamps
0 to 15 microamps
0 to 50 microamps
0 to 150 microamps
0 to 0.5 milliamps
0 to 1.5 milliamps
0 to 5 milliamps
0 to 15 milliamps
0 to 50 milliamps
0 to 150 milliamps

(e) Resistance:

Rx10 0 to 500 ohms, 10 ohms center scale
Rx100 0 to 5K ohms, 100 ohms center scale
Rx1K 0 to 50K ohms, 1K ohms, center scale
Rx10K 0 to 500K ohms, 10K ohms, center scale
Rx100K 0 to 5 Megohms, 100K ohms, center scale
Rx1 Meg 0 to 50 Megohms, 1 Megohm, center scale
Rx10 Meg 0 to 500 Megohms, 10 Megohms, center scale

SEMICONDUCTOR COMPLEMENT

0-5 The multimeter is built up entirely of solid-state circuitry with the exception of the special ac probe. Fig. 0-3 contains the semiconductor and tube complement.

Reference Designation	Type	Description	Quantity
AR1	BB3527BM	Monolithic Operational Amplifier	1
CR1, CR2	1N914	Diode	2
CR3, CR4, CR5, CR6, CR7, CR8	1N4001	Diode	6
Z1	78L15AC	Monolithic positive 15 volt regulator	1
Z2	79L15AC	Monolithic negative 15 volt regulator	1
Z3	7806C	Monolithic positive 6 volt regulator	1
DS1	LSL-3L	Light emitting diode	1
V1	EA52	UHF diode (ac probe)	1

Fig. 0-3 Semiconductor and Tube Complement

PART 1
OPERATING INSTRUCTIONS

INTRODUCTION

1-1 This part provides complete instructions for the operation of the General Purpose Electronic Multimeter. These instructions include information pertaining to general test setups as well as switch functions and descriptions of calibration adjustments permissible during operation.

FUNCTIONS OF CONTROLS AND ACCESSORIES

1-2 All switches, (except the voltage selector) adjustments, test lead connections, and the meter, pertinent to the operation of the multimeter, are located on the front panel. See Fig. 1-1.

CAUTION

Functions and ranges which may be used for ac measurements are marked in red on the front panel. On the meter, the two red scales are for ac measurement on the 0.5 and 1.5 volt ranges. Above 1.5 vac, measurements are read on the black scales.

TEST CONNECTIONS

1-3 AC PROBE

(a) The ac probe incorporates a special diode with cathode heater for making measurements up to ultra-high frequencies. The probe is positive peak responding and produces a negative dc voltage which is applied to the multimeter circuitry. The probe lead is attached to the front panel through a telephone type jack.

1-4 DC TEST LEADS

(a) For measuring dc volts, a test prod is supplied which incorporates a one megohm resistor in an insulated handle. The test lead for measuring either dc current (ma) or resistance is terminated in an alligator clip with an insulated red handle. The common test lead is also terminated in an alligator clip and an insulated black handle. All dc leads are connected to the front panel through BNC type receptacles.

FUNCTION SWITCH

1-5 The **FUNCTION** switch is a six-position, three-wafer ceramic switch which selects the appropriate circuit for the function to be measured and also determines the correct polarity of the meter. Fig. 1-2 lists the switch positions and their functions.

RANGE SWITCH

1-6 (a) The **RANGE** switch is an eleven-position, three-wafer ceramic switch which selects the appropriate resistive network to provide the desired full scale value on the meter.

(b) The switch position markings are grouped in three concentric bands and pertain to current, resistance and voltage measurements. The applicable band is determined by the selection of the **FUNCTION** switch.

(c) The markings are in black with the exception of the voltage range from 0.5 to 500. These are in red to indicate that these ranges are used for ac as well as dc measurements. Fig. 1-2 lists the switch positions and their functions.

Fig. 1-1 Front Panel Markings

Fig. 1-2

Nomenclature	Positions	Functions
Voltage Selector (S2)	115–230	Enables selection of the appropriate input supply to the primary of the power transformer T1
Power Switch (S1)	ON (up) — OFF (down)	When the unit is connected to the power source the power switch controls the application of the supply to the primary of the power transformer T1
Power On Lamp (PL1)		Lights up when voltage is applied across transformer
Function Switch (F)	(ccw) -DC AMPS +DC AMPS OHMS +DC VOLTS -DC VOLTS (cw) AC VOLTS (marked in red)	The **FUNCTION** switch determines the circuit whereby the desired measurement can be made. The selector also establishes the correct polarity for the meter
Range Switch (R)	(ccw) 1.5 μa Rx10 0.015 volts 5 μa Rx100 0.05 15 μa Rx1K 0.15 50 μa Rx10K 0.5 150 μa Rx100K 1.5 0.5 ma Rx1M 5) marked 1.5 ma Rx10M 15) 5 ma 50) 15 ma 150) in 50 ma 500) (cw) 150 ma 1500) red	The **RANGE** switch contains three calibration arcs and determines the readings for full scale deflection on the meter
Zero Adjust Screw (on meter)	Continuous rotation	Provides mechanical adjustment of pointer for zero indication

Fig. 1-2 Multimeter Operating Controls

FRONT PANEL ADJUSTMENTS

1-7 The front panel contains three adjustments: **AC ZERO**, **OHMS ADJUST** and **DC ZERO**. The **AC ZERO** potentiometer (R28) is adjusted by means of a control knob, whereas the **OHMS ADJUST** and **DC ZERO** potentiometer (R26 and R34) may be adjusted with a screwdriver or by hand as desired.

METER

1-8 The meter M1 is a D'Arsonval movement milliammeter, the polarity of which is controlled by the **FUNCTION** switch. The meter dial contains five arcs compatible with the positions of the **FUNCTION** switch. Details of the calibrations are given in Fig. 1-3.

GROUND PLUG

1-9 On the rear of the unit is a ground plug and three colored jacks. When the ground plug is placed between the black and white jacks, the chassis ground and circuit common are interconnected. When the ground plug is between the white and red jacks the chassis ground is floating.

PREPARATION FOR USE

1-10 The multimeter requires a power source of 115/230 vac ± 10%, 50 to 400Hz to operate. Before the unit can be used to measure ac voltages, a warm-up period of 20 minutes is necessary. During this period the unit can be

Arc	Calibration	Type of Scale	Color	Function
1 (upper)	0 to 5)	linear	black	DC volts and DC current
2	0 to 15)			AC volts above 5 volts
3	0 to 0.5 vac)	non-linear	red	AC volts only
4	0 to 1.5 vac)			
5	0 to ∞ with 1 ohm in center	non-linear	black	ohms

Fig. 1-3 Meter Markings

used for making dc and resistance measurements, commencing shortly after the equipment is energized. Carry out the following procedure:

(a) Select the appropriate voltage position on the rear panel. (i.e. 115/230 vac). Connect the power cord to the correct power supply.

(b) Turn the **FUNCTION** switch counterclockwise to any position other than **AC VOLTS**. Connect the test leads to their appropriate receptacle on the front panel.

CAUTION

*When plugging the ac probe into the multimeter ensure that the **FUNCTION** switch is NOT in the **AC VOLTS** (CW) position, as the diode heater would be subjected to the application of maximum voltage, resulting in damage to the probe.*

(c) Turn on the power switch and check that the power on lamp is lit.

(d) Turn the **RANGE** switch to the 0.015 or 0.050 volt position and operate the **FUNCTION** switch from **+DCV** to **-DCV**. Adjust the **DC ZERO** control until switching from **+DCV** to **-DCV** does not alter the final position of the meter pointer. The final position should coincide with the zero line on the meter scale. If it does not, it is likely that the mechanical zero of the meter requires readjustment.

(e) Insert the ground plug in the appropriate receptacle in the rear panel to obtain the desired normal or floating ground.

OPERATING PROCEDURES

1-11(a) To measure a negative or positive dc voltage, operate the **FUNCTION** switch to the **-DCV** (negative) or **+DCV** (positive) position respectively, and the **RANGE** switch fully clockwise. Connect the common test clip to the ground point of the circuit under test and place the **DC VOLT** test prod at the point to be measured. Rotate the **RANGE** switch in a counterclockwise direction until the meter pointer moves to a readable position on the dial scale. The magnitude of the voltage is then determined by the value of the reading modified by the value inscribed at the position of the **RANGE** switch.

(b) To measure negative or positive direct current, repeat the procedure in step (a) utilizing the **OHM/MA** test clip in place of the dc volt test prod, and using the **+DCA** or **-DCA** position on the **FUNCTION** switch.

(c) Resistance measurements are made utilizing the same procedure as in step (b), using the **OHMS** position on the **FUNCTION** switch. Ensure that with the test leads disconnected, the meter pointer reads full-scale deflection. If it does not do so, adjust the **OHMS ADJUST** control until full-scale deflection is achieved. Note that for proper indication, the **DC ZERO** control must have been adjusted as outlined in para 1-10 (d).

(d) To measure ac voltages, ensure that the unit has been energized for 20 minutes and that the **DC ZERO** control has been properly set as outlined in 1-10 (d). Operate the **FUNCTION** switch to **AC VOLTS**, the **RANGE** switch to the 0.5 volt range and connect the ac probe tip to the ground lead. Adjust the **AC ZERO** control until the meter pointer indicates zero, then disconnect the ground lead.

Operate the **RANGE** switch to the 500 volt range; connect the probe tip to the point to be measured and connect the ac common to the ground point in the circuit under test. Rotate the **RANGE** switch in the counterclockwise position until the meter pointer moves to a readable position on the dial scale. Modify the indication by the value of the position of the **RANGE** switch to obtain the magnitude of the voltage.

NOTE

*For frequencies up to 10 mHz, the voltage to be measured may be connected between the **ACVOLT** probe tip and the **COM** test lead. Above these frequencies, the ground lead on the probe housing should be used. For frequencies above 200 mHz it is advisable to remove the probe lead and couple to the circuit under test with a ceramic capacitor with extremely short leads or use an appropriate 'T' connector to obtain better accuracy. Also above 100 mHz the maximum voltage which may be applied to the probe input is derated from 300 v rms at 100 mHz to 100 v rms at 700 mHz.*

CAUTION

*When the **FUNCTION** switch is operated to the **ACV** position, the common test lead and **ACV** ground lead are automatically connected to chassis ground and hence to the power system ground.*

PART 2
THEORY OF OPERATION

GENERAL THEORY

2-1 This part presents complete operational theory of the General Purpose Electronic Multimeter, Model 1605M. A general introductory description of the system is given, with reference to functional diagrams, to present the theory in terms of operating functions. This is followed by a detailed analysis of the circuit and its component parts.

2-2 The multimeter is a low-voltage, high-impedance multimeter, which draws extremely low power from the circuit under test. The input to the unit is a high-impedance voltage divider on the unit and contains a dc amplifier which provides the energy to deflect the meter.

AC VOLTAGE MEASUREMENTS

2-3 Refer to Fig. 2-1. When the **FUNCTION** switch is set to the **AC VOLTS** position, the heater of diode V1 is connected directly to the +6 volt supply, since series resistor R4 is short circuited by wafer F3B. Simultaneously, the common is connected to the chassis ground.

2-4 The ac voltage to be measured is applied across diode V1 and common. The resultant negative dc is applied between point Q on the voltage divider and ground. Because of the selection of R1F and F2B, resistors R5 and R6 are connected in series with the divider, affecting a high input impedance.

2-5 A positive dc voltage derived from the 6 volt supply is applied to tap P on the voltage divider to overcome random noise present in the input. The potential applied is controlled by the **AC ZERO** adjust potentiometer, R28, which is isolated with a high resistance, R29, from the amplifier input.

2-6 Operation of the **RANGE** switch connects the amplifier input to the desired tap on the voltage divider, thus modifying the amount of input voltage necessary to cause the meter to deflect to full scale.

DC VOLTAGE MEASUREMENTS

2-7 Refer to Fig. 2-2. The negative or positive voltage to be measured is applied across the voltage divider from point Q to common. For certain selections of the **RANGE** switch, resistors R5 and R6 are added to the divider in series. The appropriate meter scale is determined by the **RANGE** switch, which switches the amplifier input to the desired tapping point on the voltage divider. The resulting signal, either negative or positive, is fed to the amplifier and the meter deflects to indicate the voltage. Wafer F1F on the **FUNCTION** switch interchanges the meter connections so that the meter deflects to the right for both positive and negative measurements.

DIRECT CURRENT MEASUREMENTS

2-8 Refer to Fig. 2-3. When the **FUNCTION** switch is in either the **-DC AMPS** or **+DC AMPS** position, the current to be measured is fed through F1B of the **FUNCTION** switch to R4B of the **RANGE** switch. Depending upon the **RANGE** switch selection which determines the meter scale, the current flows through a portion of the voltage divider to ground. This produces a voltage between O and common on the divider which causes the meter to deflect. When the negative position (**-DC AMPS**) is selected on the **FUNCTION** switch, the polarity of the meter is reversed.

RESISTANCE MEASUREMENTS

2-9 The functional diagram for resistance measurements is shown in Fig. 2-4. With the **FUNCTION** switch in the **OHMS** position, a voltage of +6 vdc is applied through series resistors, which include the **OHMS ADJUST** potentiometer, across the voltage divider between point E and common. The amplifier input is connected via wafers R3F and R4F to points on the voltage divider depending on the range selected. With no resistance connected externally, the potential at the amplifier input causes the meter to deflect to full scale. The resistance to be measured is connected to the amplifier input and therefore, across a portion of the voltage divider depending upon the **RANGE** switch setting of R3F and R4F. This causes the potential at the amplifier input to be lowered and hence the meter reading will drop. The unit is calibrated so that the meter deflection indicates the value of the unknown resistance.

DETAILED THEORY

2-10 To describe the theory of operation, the circuit may be considered to consist of five sections: test connections, switching arrangement and voltage divider, power supplies, amplifier, feedback and meter circuit. These arbitrary divisions shown in Fig. 2-5 are hypothetical and cannot be separated physically since certain components pertain to more than one section. The overall schematic diagram is shown in Fig. 7-1.

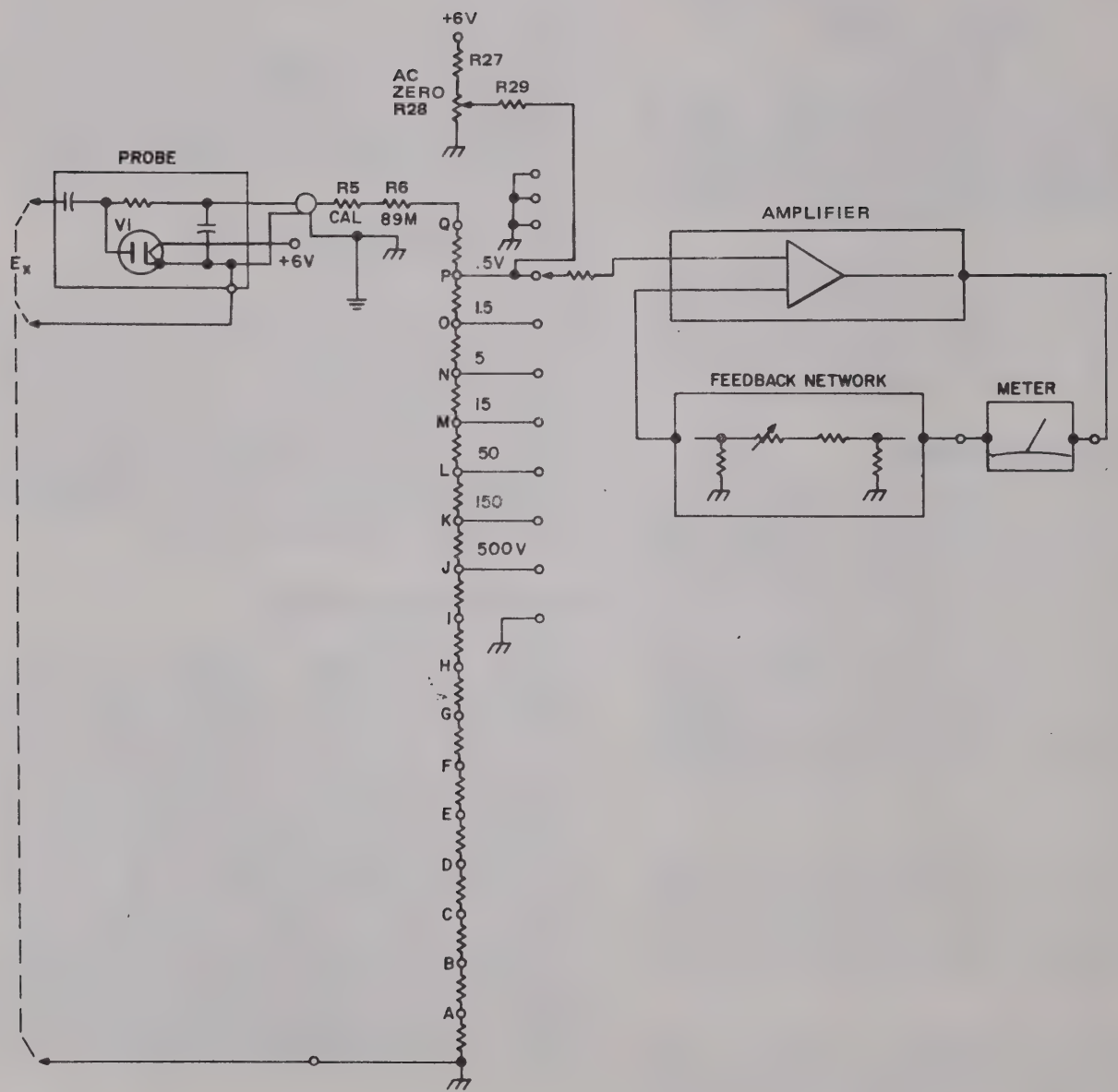


Fig. 2-1 AC Voltage Measurements – Functional Diagram

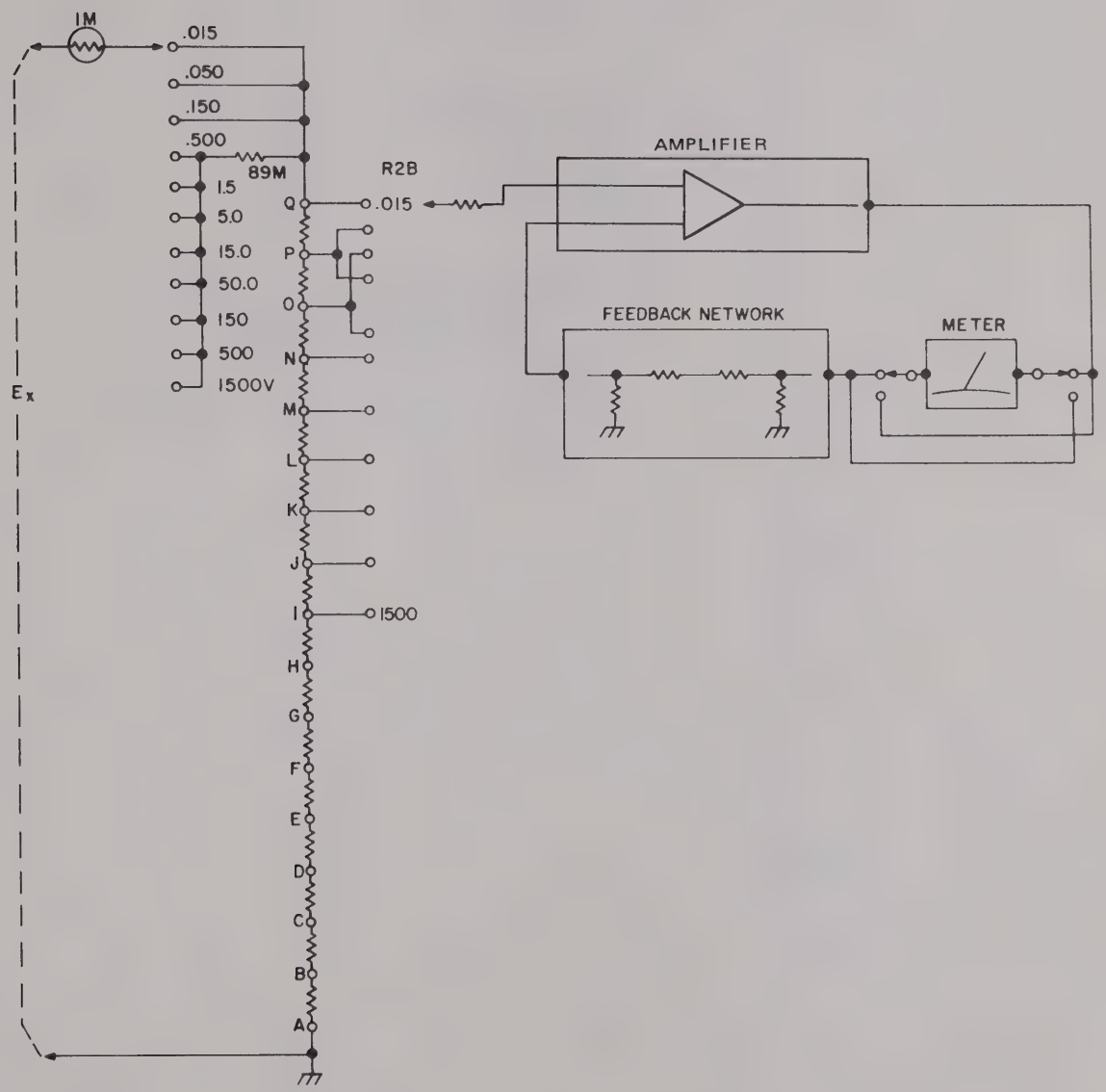


Fig. 2-2 DC Voltage Measurements – Functional Diagram

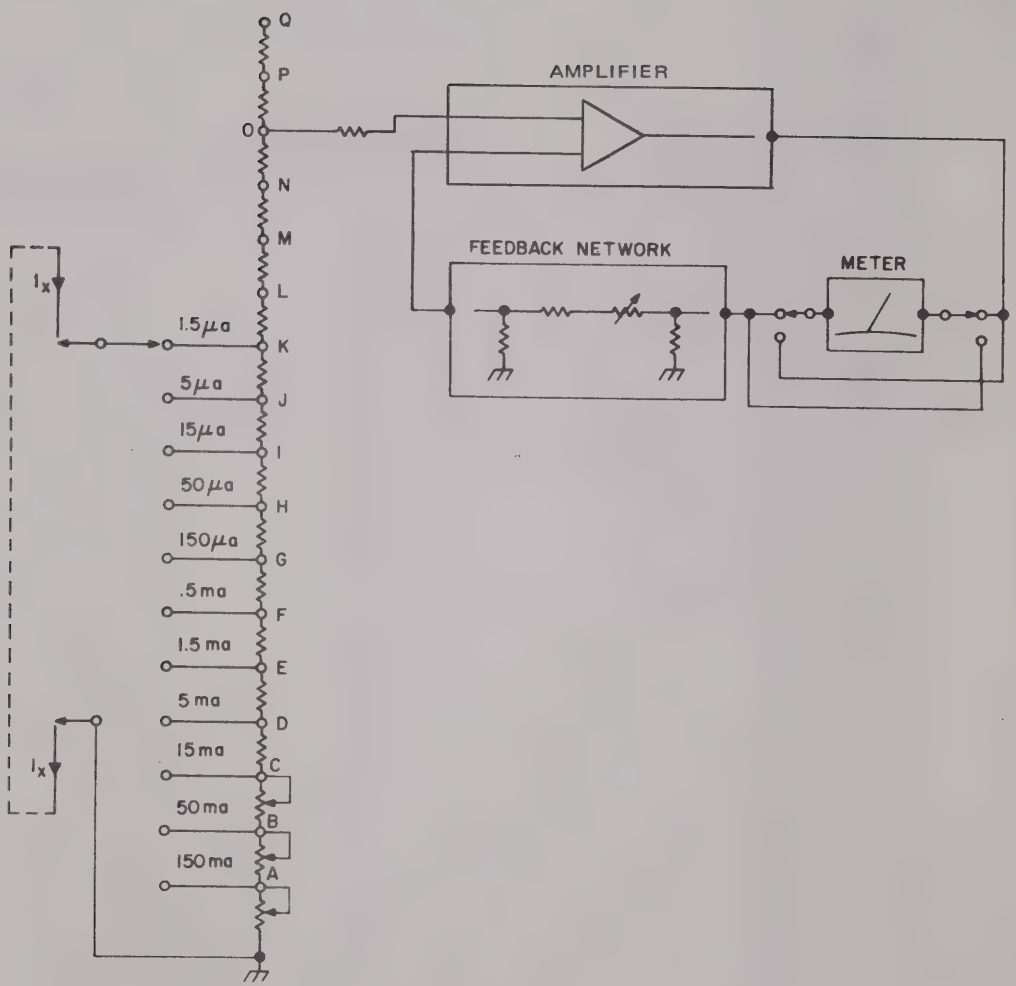


Fig. 2-3 Direct Current Measurements – Functional Diagram

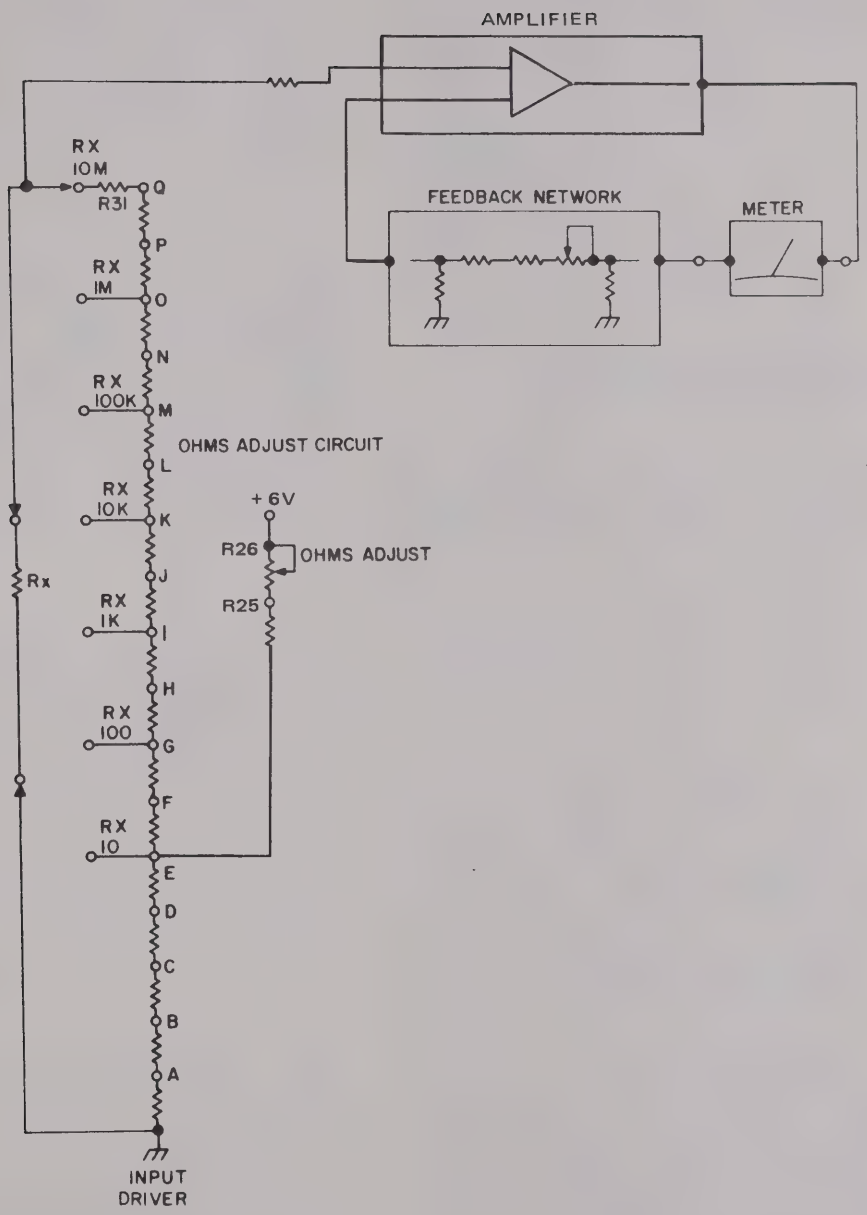


Fig. 2-4 Resistance Measurements — Functional Diagram

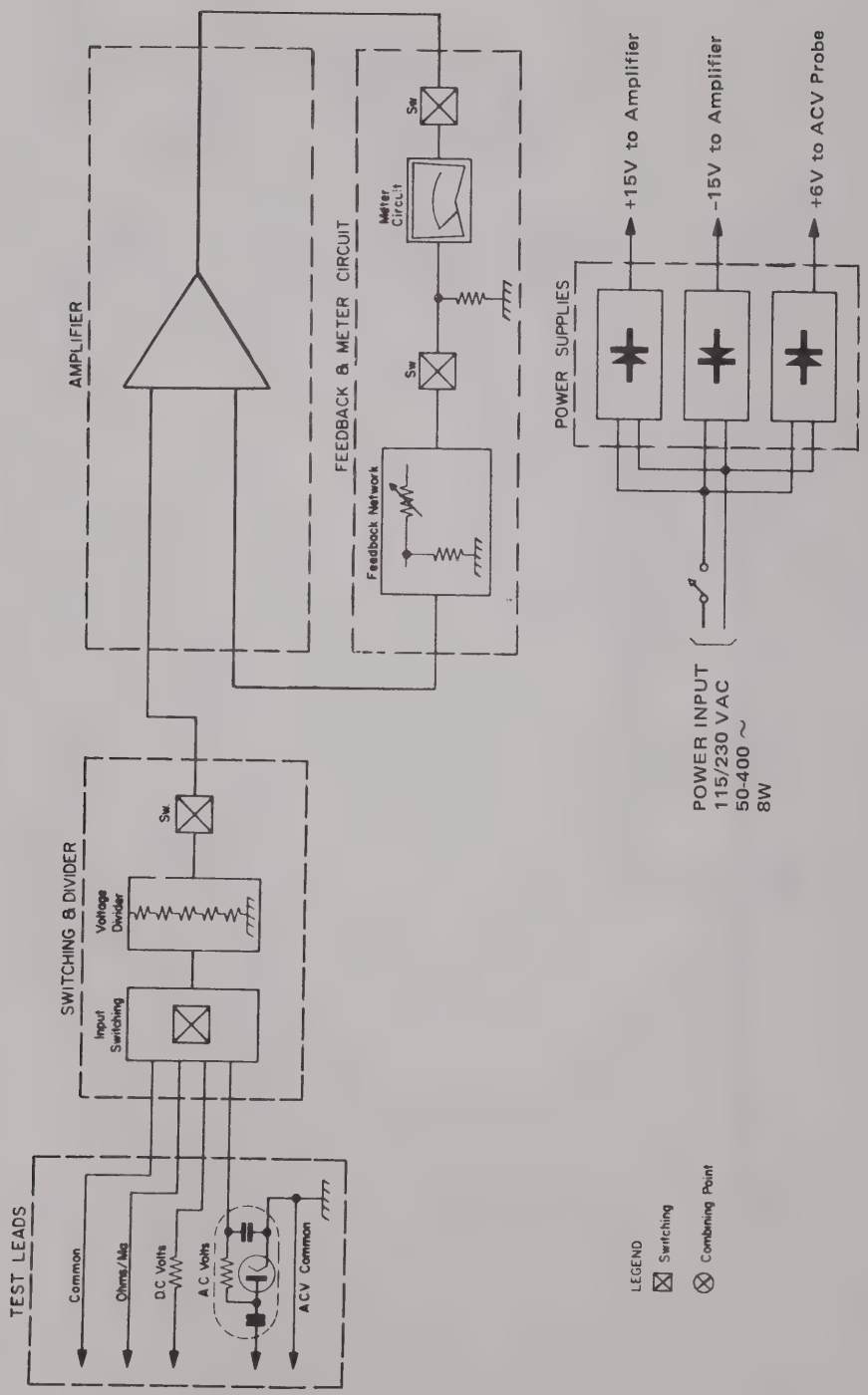


Fig. 2-5 Multimeter Model 1605M - Functional Block Diagram

TEST CONNECTIONS

2-11 There are four test leads supplied with the multimeter. Each lead connects to its own receptacle on the front panel. The ac probe contains its own integral grounding clip which must be used for high frequency measurements. The voltage to be measured is applied between the probe and its ground connection. A dc voltage is measured by applying the voltage across the dc volt test prod and the common clip. Direct current or resistance is measured by means of the (ohms/ma) test lead and the common clip.

AC PROBE

2-12 To make measurements at very high frequencies, the ac probe incorporates a UHF diode tube with a special cathode heater. The probe itself is positive-peak responding and produces a negative dc voltage. The input is through capacitor C1, directly to the plate of the diode V1. The cathode is connected to the ac ground of the circuit. The resulting dc is fed into the instrument through resistor R2. Capacitor C2, built into the probe, and capacitor C4, within the instrument, are filter capacitors.

2-13 The probe is assembled in four sections with the tube secured in a spring mount to protect it against shock. The head of the probe contains the probe tip and the input coupling capacitor C1. The tube is mounted in the body of the probe with wire connections made in the rear section. The cord which connects the probe to the multimeter, via a plug to the three-conductor jack on the front panel, is a two-lead shielded cable. The shield constitutes the ac circuit ground. One lead connects the input signal to the unit and the second lead connects the heater voltage to the tube. Capacitors C1 and C2, and resistor R2, are mounted in the probe.

2-14 Whenever the instrument is turned on, the diode heater is connected to the +6 v supply, in series with R4, thereby permitting gradual warm-up of the heater. When the **FUNCTION** switch is moved to the **ACV** position, R4 is bypassed, the full voltage is applied to the heater and it rises to operating temperature within 1 to 2 minutes. This feature eliminates extended warm-up periods before ac measurements can be made, and protects the tube from thermal shock since it is sensitive to the application of full voltage.

DC VOLTS TEST PROD

2-15 The test lead for measuring dc voltages comprises an insulated prod with an integral resistor, R1, which decreases the effect of capacitance through the cable. The shielded lead is connected to the instrument through a BNC receptacle.

OHMS, MA TEST LEAD

2-16 The shielded test lead is terminated in an alligator clip with an insulated handle and connects to the instrument through a BNC connector in the front panel.

COMMON TEST LEAD

2-17 The common test lead consists of a single shielded cable terminated in an alligator clip with an insulated handle. It connects to the circuit common within the instrument through a BNC receptacle.

SWITCHING ARRANGEMENT AND VOLTAGE DIVIDER

2-18 This section of the multimeter consists of a **FUNCTION** switch, **RANGE** switch and voltage divider network. The resistors contained in the voltage divider network are strapped to the terminals of the **RANGE** switch.

NOTE

Switch designations are made up in combinations as shown in the following examples: F2B (F = Function switch, 2 = second wafer, B = Back face of wafer); R3F (R = Range switch, 3 = third wafer, F = Front face of wafer).

2-19 The **FUNCTION** switch has six positions (12 contacts) and is comprised of three wafers. Wafer F1B (back) connects the appropriate test lead, prod or ac probe to the voltage divider network, compatible with the position marking on the front panel. Wafer F1F (front) ensures that the meter is connected with the correct polarity (e.g., in positions 1 and 5 the terminals are reversed to measure -dc amps and -dc volts respectively).

2-20 Wafer F2F connects the applicable resistive pi network in the feedback circuit of the amplifier. One half of wafer F2B connects the correct output from the voltage divider to the input of the amplifier. The other half of this wafer modifies the voltage divider during ac and dc voltage measurements.

2-21 During resistance measurements one half of wafer F3F is used to connect +6 vdc across the 10-ohm portion of the divider network. In conjunction with the other half of wafer F3F, +6 vdc is applied across the 3-megohm portion of the voltage divider during ac voltage measurements. At the same time, the selection of wafer F3B bypasses the series load resistor in the heater of the ac probe and full voltage is applied to the diode heater. Simultaneously the ac ground is connected to the chassis ground, thereby overriding the connection of the ground plug.

2-22 The **RANGE** switch has 11 positions (11 contacts) and is comprised of four wafers. A portion of wafer R1F functions in parallel with F2B to modify the voltage divider. The other portion is used to modify the divider network, in conjunction with F3F. Wafer R1B selects the resistors and calibration potentiometers of the pi network in the feedback circuit for the appropriate range for measurement of ac voltage.

2-23 Wafer R2F selects the pi network for the appropriate range for measurement of dc voltage. Simultaneously, wafer R2B selects the appropriate portion of the voltage divider network which is connected to the amplifier unit.

2-24 Wafers R3F and R3B are used to select the correct portion of the voltage divider for measurements of resistance and ac voltage respectively.

2-25 Wafer R4F is connected in parallel with wafer R3F. Wafer R4B selects the correct portion of the voltage divider during measurement of direct current.

2-26 The voltage divider network consists essentially of 17 resistors in series ranging in value from 6 megohms to 0.1 ohms. Permanent taps are made at 10 ohms, 1 megohm, 3 megohms and 9 megohms. The total resistance value of the voltage divider is further modified by the addition of resistors (e.g., R5, R6) during certain function and range selections.

POWER SUPPLIES

2-27 The multimeter is operated from a 115/230 vac ±10%, 50 to 400 Hz supply, which is connected across the primary of power transformer T1. The appropriate input is connected via voltage selector S2. It arranges the primary of T1 in a configuration which accommodates the input voltage. Power **ON-OFF** switch S1 and fuse F1 are placed in series with the primary windings. The power-on indicator DS1 is in parallel with the 6 volt secondary of T1, and lights when S1 is closed. See Fig. 7-1.

2-28 One of the secondary windings produces both +15 vdc and -15 vdc for use by the dc amplifier. The positive and negative voltages are generated by grounding the center tap of the secondary and using a full wave bridge comprised of CR3 through CR6. Filtering is provided via C10 and C11. Integrated circuit voltage regulators Z1 and Z2 provide stable +15 v and -15 v supplies respectively to the dc amplifier and reduce effects due to shifts in the ac line voltage, or varying load demands by the dc amplifier. Additional filtering to reduce noise and improve transient response of Z2 is provided by C12.

2-29 The remaining winding of T1 produces the positive 6 volt supply to be applied to the V1 filament in the ac probe, as well as the ohms adjust and ac zero circuits. Full wave rectification is provided by CR7 and CR8. Filtering is accomplished by C13. Voltage regulator Z3 stabilizes the voltage going to V1 in the ac probe to prevent shifts in the ac line voltage from affecting the accuracy.

DC AMPLIFIER

2-30 Irrespective of the measurement being made, a signal is fed through F2B of the **FUNCTION** switch to the input of the dc amplifier. The input of the amplifier is pin 3 on AR1.

2-31 Preceding AR1 are four separate circuits. Resistor R30 provides attenuation of the input signal. C5 is part of a feedback network which speeds up the action of the circuit. Diodes CR1 and CR2 conduct when a large over-voltage, either positive or negative, is developed across them (i.e., voltages appreciably in excess of 100 millivolts) and hence protect the input to the amplifier. A filter formed by R31 and C5 attenuates undesired noise and ac components which may be present on the input.

2-32 The dc amplifier is a highly stable, monolithic device. Its impedance is very high so that it draws negligible current from the dc input. The resultant feature is that minute power is drawn from the circuit under test.

2-33 The output voltage of the dc amplifier, pin 6 of AR1, is set to zero by means of R34, the dc zero control. This potentiometer is connected through R32 and R33 to the offset voltage adjustment terminals of AR1. Any non-zero output voltages due to bias current effects or internal voltage offset errors within AR1 can be nulled out using R34, and thus zero the meter.

FEEDBACK AND METER CIRCUIT

2-34 The meter M1 is connected directly to the output of AR1. Current will flow out or in pin 6 of AR1 depending upon whether the input voltage at pin 3 is positive or negative, respectively. If current flows out of AR1, the meter deflects positively to the relative scale position. Should the current be negative, i.e. flow into AR1, the polarity of the meter is changed by section F1F and the meter then deflects in a clockwise direction indicating the magnitude of the negative measurement.

2-35 The feedback circuit is connected to the lower side of the meter at R49. The feedback is a function of the relationship between the voltage drop developed across R49 and the pi circuit for the particular measurement being made. The particular pi circuit is determined by the selection of both the **FUNCTION** and **RANGE** switches, and specifically wafers F2F, R2F, and R1B. These networks contain calibration potentiometers and fixed resistors. Balancing the input takes place at pin 2 of AR1, and the feedback circuit may be defined as a potentiometric gain-adjust circuit.

PART 3
UNIT MAINTENANCE INSTRUCTIONS

PERFORMANCE CHECKS

3-1 The following procedure determines whether or not the unit is working normally. To check the accuracy of calibration of the unit, readings should be taken and compared to a standard. Proceed as follows:

(a) Move the **FUNCTION** switch to the **+DCV** position and the **RANGE** switch to the 1500 position.

(b) Operate the voltage selector, then connect the unit to the appropriate power source. Move the **POWER** switch to the **ON** position. Observe that the **POWER ON** light operates.

(c) Connect all test leads to the front panel of the unit.

(d) Connect the COM clip to the tip of the DCV probe.

(e) Turn the **DC ZERO** control to its maximum clockwise position and check that the meter pointer deflects at least 3 percent of full scale to the right.

(f) Turn the **DC ZERO** control to its maximum counterclockwise position and move the **FUNCTION** switch to the **-DCV** position. Check that the meter pointer again deflects at least 3 percent of full scale to the right.

(g) Repeat steps (e) and (f) with the **RANGE** switch in the 0.015 (max ccw) position.

(h) Move the **FUNCTION** switch to the **+DCA** position and the **RANGE** switch to the 1.5 μa position. Connect the OHMS/MA test clip to the COM test clip.

(j) Turn the **DC ZERO** control to its maximum clockwise position and check that the meter pointer deflects at least 3 percent of full scale to the right.

(k) Turn the **DC ZERO** control to its maximum counterclockwise position and the **FUNCTION** switch to the **-DCA** position. Check that the meter pointer again deflects at least 3 percent of full scale to the right.

(m) Repeat steps (h), (j) and (k) with the **RANGE** switch in the 150 ma position.

(n) Set the **DC ZERO** control for zero. See para 1-10 (d).

(p) Move the **FUNCTION** switch to the **OHMS** position and the **RANGE** switch to the Rx10 position. Check that the meter pointer deflects to the right.

(q) Turn the **OHMS ADJUST** control to the maximum counterclockwise position and check that the meter pointer drops to at least 10 percent below full scale deflection.

(r) Turn the **OHMS ADJUST** control to the maximum clockwise position and check that the meter pointer deflects over full scale deflection to the right.

(s) Set the **OHMS ADJUST** control for full scale deflection and connect the **OHMS** test lead to the COM test lead. Check that the meter pointer reads ZERO.

(t) Repeat steps (q) and (s) on the Rx100, Rx1K, Rx10K, Rx100K, Rx1M and Rx10M positions of the **RANGE** switch.

(u) Connect the ground clip on the **ACV** probe to the probe tip. Move the **RANGE** switch to the 0.5 v range and the **FUNCTION** switch to the **ACV** position.

(v) After approximately 2 minutes warmup, check that operating the **AC ZERO** control in the clockwise direction causes the meter pointer to deflect to the right, and that operating the control in the counterclockwise direction causes the meter pointer to deflect to the left.

(w) Set the **AC ZERO** to zero. Refer to para 1-11 (d).

(x) Move the **RANGE** switch to the 500 v range and disconnect the GROUND clip from the probe tip.

(y) Measure the power line voltage, using only the probe tip. The meter pointer should deflect to the right and indicate the value of the power line voltage. Where the line voltage is below 150 vac, move the **RANGE** switch to the 150 v range and check that the value of line voltage indicated on this range matches that shown on the 500 v range within the specified tolerance of the instrument.

TROUBLE SHOOTING

3-2 The procedures by which faults within the multimeter can be isolated are limited to symptoms which would be apparent during operation. The majority of the components are mounted on printed circuit boards and, since field servicing of these assemblies is not recommended, no attempt is made to predict a faulty component. Fault isolation is therefore limited to an electronic section of the equipment. See Fig. 3-1.

	Symptom	Probable Fault	Corrective Action
1	Power lamp does not light. Power connected and power on switch (S1) closed	Power supply off	Check power source and line cord connection.
		Fuse F1 blown	Check power source. Check line cord and line cord connection. Replace F1.
		Power supply defective	Refer to Repair Procedures.
		Power switch (S1) or selector (S2) defective	Replace switch S1 or S2.
2	Meter does not register for any function. Power light on	Meter connections faulty	Remove wrap-around, inspect and if necessary repair connections to meter.
		Faulty meter movement	Replace meter.
3	Meter does not indicate on **DC VOLTS** only	Damaged test lead	Check condition of test lead and **DC VOLTS** probe.
		Faulty connection	Check panel connection.
		Faulty **FUNCTION** switch	Refer to Repair Procedures.
4	Meter does not indicate on **DCA** only	Damaged test lead or faulty connection	Check condition of test lead and check panel connection.
		Faulty **FUNCTION** switch	Refer to Repair Procedures.
5	Meter does not indicate on **OHMS** only	Incorrect setting of **RANGE** switch	Check **RANGE** switch setting.
		Test lead shorted between shield and center conductor, or faulty connection	Check condition of test lead and check panel connection.
		Faulty **OHMS ADJUST** control or R25 open	Refer to Repair Procedures.
		Broken wiring to **OHMS ADJUST** control	Remove wrap-around, inspect wiring, repair connection.
		Faulty **FUNCTION** switch	Refer to Repair Procedures.
6	Meter does not indicate any resistance value. Pointer remains at full scale deflection	Test lead open circuit or faulty connection	Check condition of test lead and check panel connection.

Fig. 3-1 Trouble Shooting Chart (Page 1 of 2)

	Symptom	Probable Fault	Corrective Action
7	Meter does not indicate on **AC VOLTS** only	Damaged test lead or faulty connection	Check condition of test lead and check connection.
		Diode V1 in AC probe defective	Replace V1.
		Faulty **FUNCTION** switch	Refer to Repair Procedure.
8	**DC ZERO** control does not function	Faulty control, wiring, or component	Refer to Repair Procedure.
9	**OHMS ADJUST** control does not function	Faulty control, wiring, or open resistor	Refer to Repair Procedure.
10	**AC ZERO** control does not function. Meter deflects off scale to the left	Damaged test lead or faulty connection	Check condition of test lead and check panel connections.
		Diode V1 in AC probe defective	Replace V1.
		Faulty control, wiring, or component	Refer to Repair Procedure.
11	Meter indication does not compare with a standard on any one function	Out of calibration	Refer to Calibration Procedure.

Fig. 3-1 Trouble Shooting Chart (Page 2 of 2)

PART 4
REPAIR, OVERHAUL AND CALIBRATION

GENERAL

4-1 This instrument is a complex unit and fault isolation and repair should not be undertaken without the proper tools, test equipment and facilities.

4-2 To repair and replace parts, follow specific instructions as laid down in this manual.

4-3 Fault analysis is divided into four sections as follows:

(a) Power supplies

(b) Amplifier and input circuit

(c) Feedback circuit

(d) Switches and front panel controls

4-4 This division is an arbitrary one for ease of description only, since each section may affect one or more of the other sections. It is assumed that the trouble shooting procedure in Part 3 has been followed and the fault has been established generally.

POWER SUPPLIES

4-5 To analyze faults within the power supplies the following equipment is required.

(a) Standard multimeter, 20,000 ohms per volt, capable of measuring ac volts, dc volts, dc amps and ohms.

(b) Standard screwdriver, medium blade.

4-6 The power supplies are located on the large printed circuit board, mounted on the right side of the chassis, when viewed from the front of the unit. Transformer T1 is mounted inside the chassis. Proceed as follows:

(a) Remove the screws which secure the wrap-around case.

(b) When the fault symptom is that the fuse blows when the power is turned on, remove the bottom panel of the unit, inspect and check power wiring, transformer and power switch before proceeding with further tests.

(c) Measure the voltages on the printed circuit board and compare with the values given in Fig. 4-1.

AMPLIFIER

4-7 The amplifier circuit board is mounted on the right side of the chassis when viewed from the front of the unit as follows:

(a) Using a VTVM with at least 11 megohms input impedance, measure the voltages at AR1 as indicated in Fig. 4-2.

(b) Note that if unable to set **DC ZERO**, the fault could be in R32, R33, R34, R52, or AR1.

FEEDBACK CIRCUIT

4-8 Most of the feedback circuit is located on the calibration board. The components are all resistive. Possible faults are open circuited or short circuited resistors or broken wire. Replace, repair and recalibrate as necessary.

NOTE

Should it be necessary to replace any component in this circuit, the unit must be recalibrated.

SWITCHES AND FRONT PANEL CONTROLS

4-9 Switches are ceramic and quite delicate; therefore mounting the assembly in a jig for repair is recommended. Proceed as follows:

(a) To replace a resistor, cut the leads of the faulty resistor.

(b) Precut the leads of the replacement resistor and bend them. The lead should be slightly hooked.

Location	Voltage
Z1 input	+22 vdc ±20%
Z1 output	+15 vdc ±10%
Z2 input	−22 vdc ±20%
Z2 output	−15 vdc ±10%
Z3 input	+11 vdc ±20%
Z3 output	+ 6 vdc ±10%

Fig. 4-1 Power Supply Voltages

AR1 Pin Number	DC Voltage
1	−15 v ±10%
2	15 mv or less
3	15 mv or less
4	−15 v ±10%
5	−15 v ±10%
6	200 mv or less
7	+15 v ±10%
8	15 mv or less

Fig. 4-2 Amplifier Voltage Check

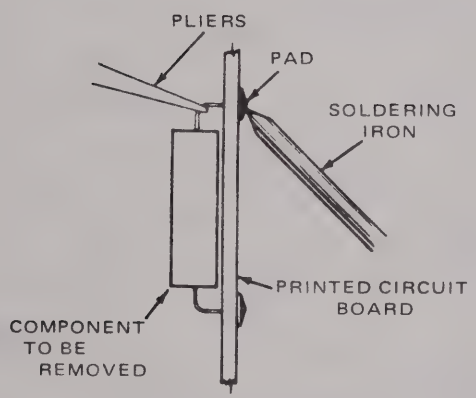
(c) Apply the soldering iron to the tab and remove the end of the old lead.

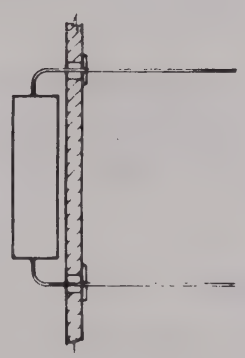
(d) Apply the iron to the tab; insert the lead of the replacement resistor and resolder. Repeat for the other end.

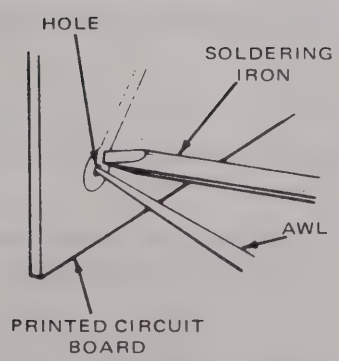
REPLACEMENT OF COMPONENTS

4-10 The procedure for replacing components, reference Fig. 4-3, is as follows:

(a) Hold the board in either the vertical or horizontal position with the printed side down. Apply heat sparingly to the lead of the component to be removed from printed side of board. (Use a well-tinned soldering iron.)







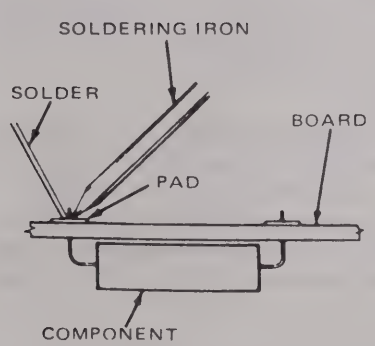


Fig. 4-3 Servicing Etched Circuit Boards

(b) Remove the component from the board one lead at a time. It may require heating the leads alternately and "wiggling" the component out of the board.

(c) Reheat the solder in the hole and allow as much solder as possible to adhere to the soldering iron. Immediately insert an awl into the hole from the printed side to clean out the hole. This procedure should be followed carefully or extensive damage to the printed circuit board will result.

(d) For many-leaded items, heat one lead at a time and withdraw the lead as far as possible. Repeat this procedure for remaining leads in sequence until the component is "wiggled" loose.

(e) Bend the clean, tinned leads of new component and carefully insert them in the holes. (Do not force the component. If the leads do not insert easily, reheat the pad and clean the holes as described in step (c).)

(f) Hold the part against the board and solder the leads from the printed side of the board. Do not leave a large quantity of solder on the pad. The ideal amount can be determined by observing the other connections made during duction.

CALIBRATION PROCEDURES

4-11 All calibration points are located on the printed circuit board on top of the chassis. See Fig. 4-4.

DC VOLTS

4-12 Calibration of the dc volts circuitry requires:

(a) A calibrated source of dc voltage with an accuracy of at least 0.25% (e.g., Harrison Lab Type 6920B) and a decade voltage divider with an accuracy within at least 0.1% (e.g., General Radio Type 1454-A).

(b) Alternately a regulated adjustable dc voltage supply with line voltage regulation and ripple less than 10 millivolts peak-to-peak is acceptable (e.g., Hickok 5055 or 5056) together with a decade voltage divider with an accuracy within at least 0.1% (e.g., General Radio Type 1454-A) and an accurate voltmeter 0-150 v ±0.5%, (e.g., Yew Type 121158).

4-13 Fig. 4-5 shows diagrammatically the alternate calibration set-ups using the equipment recommended in steps (a) and (b). Carry out the following procedure:

(a) Remove the wrap-around cover from the multimeter to provide access to the calibration potentiometers.

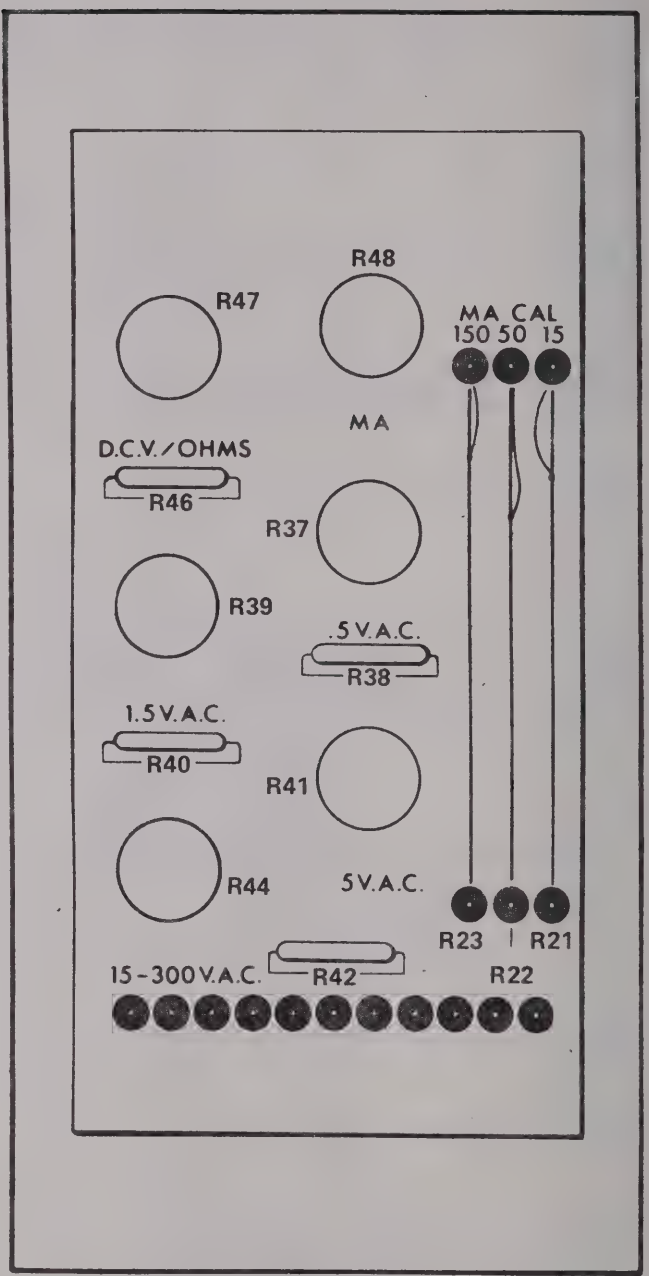


Fig. 4-4 Calibration Circuit Board, Location Diagram

(b) Operate all equipment in accordance with the procedures recommended in the appropriate operating manuals. Ensure that the **FUNCTION** switch of the multimeter is in the **+DCV** position and the **RANGE** switch is in the 0.050 volt position.

(c) Allow at least two minutes warmup prior to making any adjustments to ensure that the unit is stabilized.

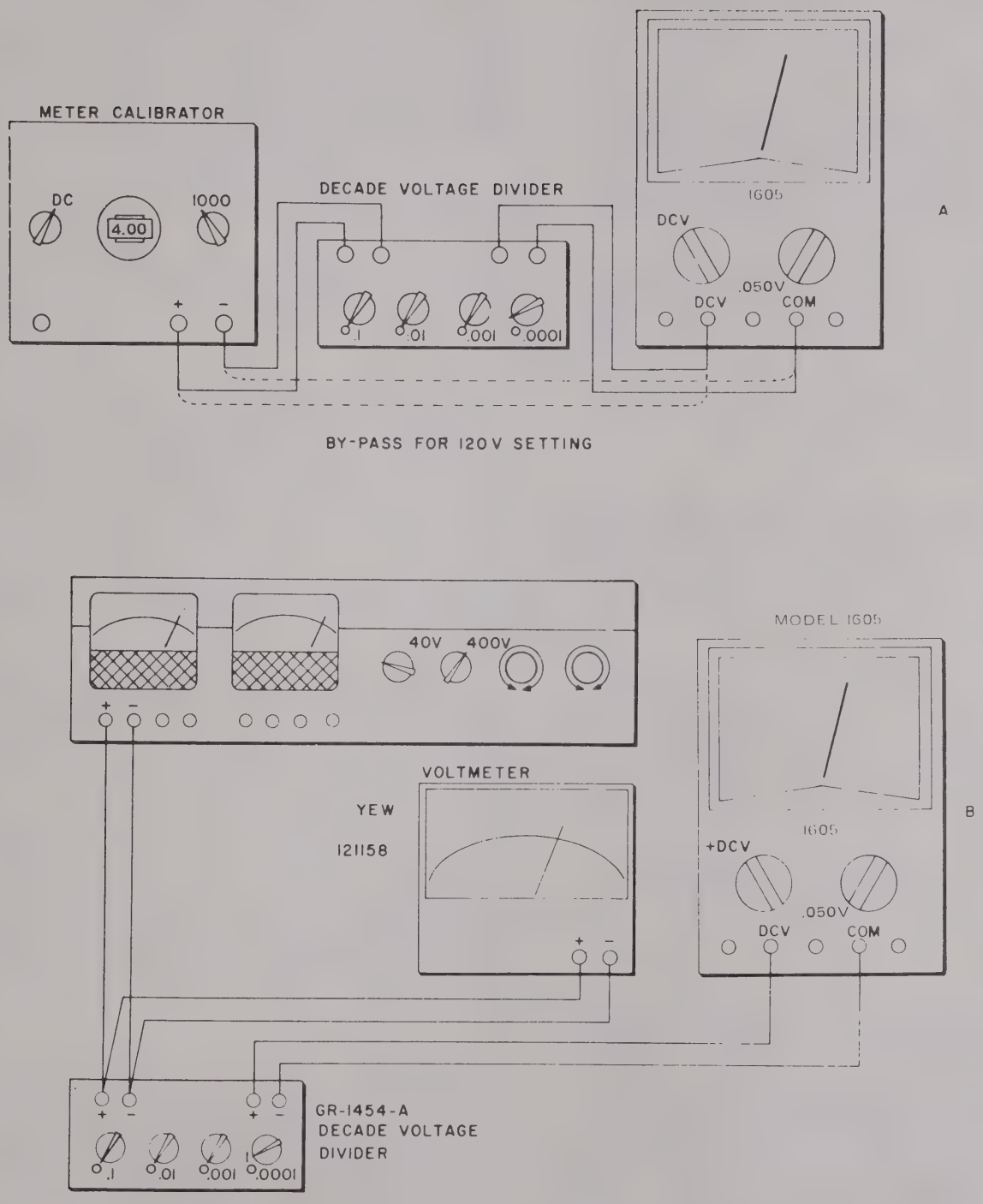


Fig. 4-5 Test Set-Up for Calibration of DC Volts Circuitry

(d) Connect the COM test lead clip to the tip of the DC VOLT probe. Check, and if necessary, adjust the **DC ZERO** control.

NOTE

DC ZERO *is properly adjusted when the action of switching the* ***FUNCTION*** *switch from +**DCV** to -**DCV** does not alter the final position of the meter pointer. This position should coincide with the zero line on the meter dial. If not, then it is likely that the meter zero adjust screw requires resetting.*

(e) If the **DC ZERO** control does not have the range to zero the meter, set the control half way in its rotation and adjust R52 (ZERO CAL) until the meter is coarsely zeroed. Then use the **DC ZERO** control for a precise zero adjustment.

(f) Connect the equipment in accordance with the test set-up, Fig. 4-5, and operate the **RANGE** switch to the 1500 volt position.

(g) Disconnect the COM test clip from the DC VOLT probe and apply a calibrated 40 millivolts dc signal to the instrument. Turn the **RANGE** switch to the 0.050 volt position and note the meter reading. The reading should be 40 ±1.0 millivolts. Adjust potentiometer R47 (DCV/OHMS) until this value is obtained.

(h) Operate the **RANGE** switch to the 150 v position and apply a calibrated 120 vdc to the instrument. Note the meter reading. The reading should be 120 ±3 volts. If this value is not obtained, substitute resistors of alternate values for R5 (connected between F3B1 and F3B2 on the side of the **FUNCTION** switch) until this reading is achieved.

(i) The multimeter is now calibrated on **DC VOLTS**.

DC AMPERES

4-14 Calibration of the dc amperes circuitry requires:

(a) A calibrated dc source with an accuracy of at least 0.25% (e.g., Harrison Lab Type 6920A Meter Calibrator.)

(b) Alternately, use a 6-volt battery; a fixed 100K ohm ±5%, 0.5 watt resistor; an adjustable resistance capable of dissipating up to one watt (e.g., Hickok Model DEC-720 decade resistance box (0.5%); a microammeter, 0-100 μa, accuracy at least 0.5% (e.g., Yew Model MPF 121105 microammeter); a milliammeter, 0-15, 0-50, 0-150 ma, accuracy at least 0.5% (e.g., Yew Model MPF 121138 milliammeter, 0-30/100/300 ranges).

4-15 Fig. 4-6 shows diagrammatically the alternate calibration set-ups, using the equipment recommended in para 4-14 (a) and (b). Carry out the following procedure:

(a) Remove the wrap-around cover from the multimeter to provide access to the calibration potentiometers.

(b) Operate all equipment in accordance with the procedures recommended in the appropriate operating manuals. Ensure that the **FUNCTION** switch of the multimeter is in the **+DCA** position and the **RANGE** switch is in the 50 microampere position.

(c) Allow at least two minutes warmup prior to making any adjustments to ensure that the unit is stabilized.

(d) Connect the COM test lead clip to the DCA/OHMS test lead clip. Check, and if necessary, adjust the **DC ZERO** control.

NOTE

DC ZERO *is properly adjusted when the action of switching the* ***FUNCTION*** *switch from +**DCA** to -**DCA** does not alter the final position of the meter pointer. This position should coincide with the zero line on the meter dial. If it does not, then it is likely that the meter zero-adjust screw requires resetting.*

(e) Disconnect the COM and DCA/OHMS test leads. Connect the equipment in accordance with the appropriate test set-up, Fig. 4-6. Move the **RANGE** switch to the 150 ma position.

(f) Apply a calibrated current of 40 microamperes dc to the instrument. Operate the **RANGE** switch to the 50 μa position and note the meter reading. The reading should be 40 ±1.5 microamperes. Adjust potentiometer R48 (MA CAL) until this value is obtained.

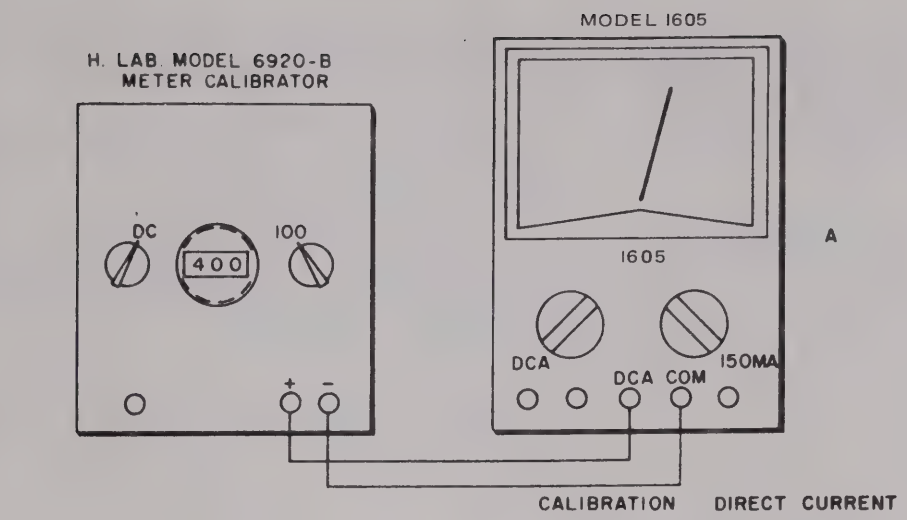
(g) Operate the **RANGE** switch to the 150 ma position.

(h) Apply a calibrated current of 120 milliamperes dc to the instrument and note the meter reading. The reading should be 120 ±4.5 milliamperes. If this value is not obtained, using a soldering iron, adjust the sliding contact on R23 (150 MA CAL) until the reading is achieved.

NOTE

When making this adjustment it should be remembered that the application of heat from the soldering iron will cause an increase in resistance. Thus, to ensure that a final setting has been reached, readings should not be taken until after the joint between the contact and the resistance wire has cooled.

(j) Apply a calibrated current of 40 ma to the instrument and operate the **RANGE** switch to the 50 ma position. Note the meter reading. The reading should be 40 ±1.5 ma. If this value is not obtained, using a soldering iron, adjust the sliding contact on R22 (50 MA CAL) until the reading is achieved.



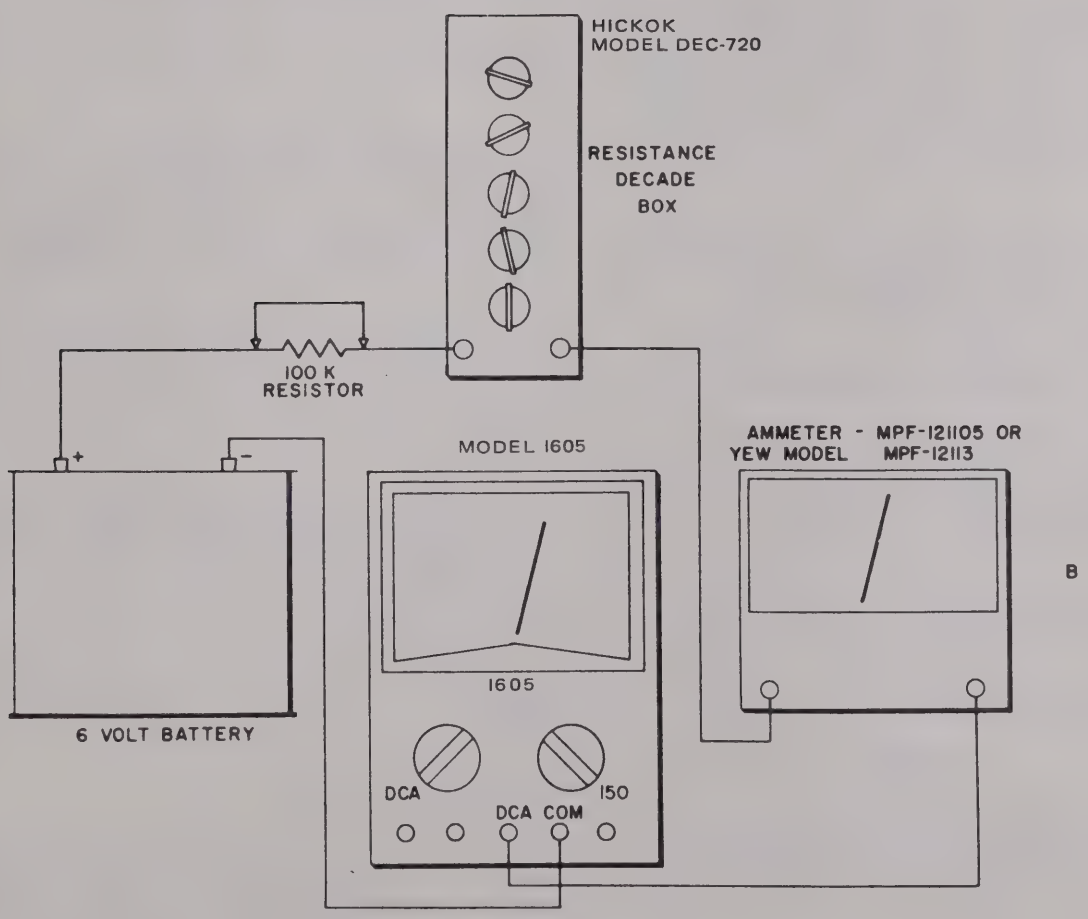


Fig. 4-6 Test Set-Up for Calibration of DC Amperes Circuitry

(k) Apply a calibrated current of 12 ma to the instrument. Operate the **RANGE** switch to the 15 ma position and note the meter reading. The reading should be 12 ±0.45 ma. If this value is not obtained, using a soldering iron, adjust the sliding contact on R21 (15 MA CAL) until the reading is achieved.

(m) Recheck, and if necessary, readjust the settings in steps (h), (j) and (k).

(n) The instrument is now calibrated for direct current measurement.

AC VOLTS

4-16 Calibration of the ac volts circuitry requires:

(a) A calibrated ac voltage source (400 cps) with an accuracy of at least 0.25% (e.g., G and E Bradley Model 125B, or Hewlett-Packard Model 738AR).

(b) Alternatively use a low frequency signal generator, capable of at least 15 v rms output with harmonic distortion less than 1% (e.g., Hickok Model 2975M); a decade voltage divider with an accuracy of at least 0.1%, (e.g., General Radio 1454-A); an ac voltmeter, 1000 ohms/volt, 0-15 volts. Accuracy at least 0.5% (e.g., YEW SPF 122153).

4-17 Fig. 4-7 shows diagrammatically the alternate calibration set-ups using the equipment recommended in para 4-16 (a) and (b). Proceed as follows:

(a) Remove the wrap-around cover from the multimeter to provide access to the calibration potentiometers.

(b) Operate all equipment in accordance with the procedures recommended in the appropriate operating manuals. Ensure that the **FUNCTION** switch is in the **+DCV** position and the **RANGE** switch is in the 0.015 v position.

(c) Allow at least a two minute warmup prior to making any adjustments to ensure that the unit is stabilized.

(d) Check, and if necessary, adjust the **DC ZERO** control as described in para 4-12 (d).

NOTE

*It is essential that the **DC ZERO** be adjusted properly prior to proceeding with the ac volts calibration. Failure to do so could result in errors up to 3 percent FSD.*

(e) Connect the ground clip on the **AC VOLTS** probe to the probe tip. Operate the **FUNCTION** switch to **ACV** and the **RANGE** switch to the 0.5 volt range.

(f) Allow 15 minutes warmup for the tube in the probe, prior to making any further adjustments.

(g) Adjust the **AC ZERO** control on the front panel until the meter pointer rests on the zero line on the meter scale.

(h) Disconnect the ground clip from the probe tip and operate the **RANGE** switch to the maximum clockwise position. Connect the equipment in accordance with the appropriate test set-up, Fig. 4-7.

(j) Apply a calibrated input of 0.4 vac, 400 cps to the unit. Operate the **RANGE** switch to the 0.5 vac range and note the meter reading. The reading should be 0.4 ±0.15 vac.

NOTE

On the 0.5 and 1.5 vac range readings are taken on the two middle nonlinear scales (red). All others are read on the upper linear scales (black).

(k) If the reading in step (j) is not obtained, adjust potentiometer R37 (0.5 vac CAL) until the value is achieved.

(m) Operate the **RANGE** switch to the 1.5 vac range and apply a calibrated input of 1.2 vac, 400 cps to the unit. Note the meter reading. The reading should be 1.2 ±0.045 v. If the reading is not obtained, adjust potentiometer R39 (1.5 vac CAL) until the value is achieved.

(n) Operate the **RANGE** switch to the 5 vac range and apply a calibrated input of 4 vac, 400 cps to the unit. Note the meter reading. The reading should be 4 ±0.15 vac. If the reading is not obtained, adjust potentiometer R41 (5 vac CAL) until the value is achieved.

(p) Operate the **RANGE** switch to the 50 vac range and apply a calibrated input of 40 vac, 400 cps to the unit. Note the meter reading. The reading should be 40 ±1.50 vac. If the reading is not obtained, adjust potentiometer R44 (15 – 300 vac CAL) until the value is achieved.

(q) The instrument is now calibrated to measure ac voltage.

CLEANING MATERIALS

4-18 The case and all components may be cleaned with a stream of filtered, compressed dry air of less than 30 psi pressure. Remove any grease spots with a high quality cleaning fluid used sparingly and dust with a lint-free cloth and cleaning brush. Water may be used for cleaning large exposed surfaces where evaporation can readily take place. For general cleaning purposes the following mixed solution

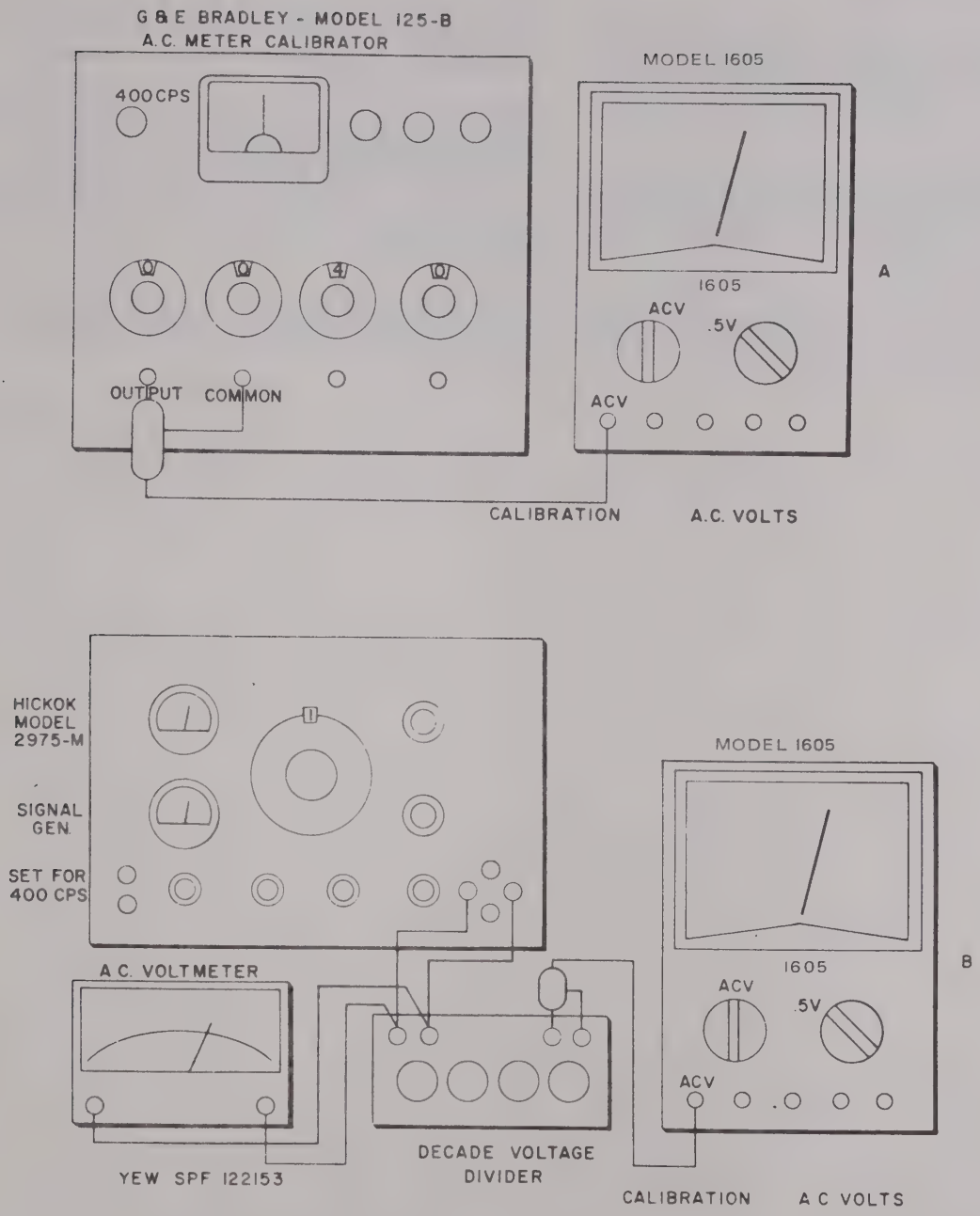


Fig. 4-7 Test Set-Up for Calibration of AC Volts Circuitry

is recommended: 70 percent dry cleaning solvent (Federal Specification P-S-661), 5 percent trichloroethylene (Federal Specification O-T-236) and 25 percent methylene chloride (Air Force Specification AN-M-37).

4-19 It is advisable that chassis parts be disturbed as little as possible. Generally, clean only with compressed air. Do not move parts during cleaning and do not score chassis surfaces.

4-20 Clean exterior surfaces of fixed capacitors with a general cleaning solution and a soft brush. Clean exterior surfaces with a soft cloth moistened with a general cleaning solvent. (Refer to para 4-21.)

4-21 Clean the transformers with a clean dry cloth, moistened with a general cleaning solution. Remove corrosion with crocus cloth or No. 0000 sandpaper. Remove particles with a fine brush and then clean with a general cleaning solvent.

4-22 Clean dirty connectors with a fine brush dipped in general cleaning solution. Dry thoroughly. Clean corroded contacts with crocus cloth or No. 0000 sandpaper.

4-23 Clean the meter case and cover glass with a dry cloth. If dirt persists use a cloth moistened with a general cleaning solvent. Remove dirt from mountings and connections with a stiff brush moistened with a general cleaning solution. Remove corrosion from mountings and connections with No. 0000 sandpaper.

4-24 Spray the underside of printed circuit boards lightly with a coating of Humi-seal Type 1B15, or equivalent.

PART 5
PACKAGING, PRESERVATION AND STORAGE

PACKAGING

5-1 The multimeter and test leads are packaged in a corrugated carton adequately protected by folded corrugated wedges. To pack the unit, proceed as follows:

(a) Disconnect the test leads from the front panel, coil and tape them.

(b) Place the leads in individual plastic bags.

(c) Secure the ground plug on the rear of the unit using tape.

(d) Fit the corrugated pad in the bottom of the container.

(e) Seal the unit in a vapor barrier together with desiccant and place it in the corrugated cardboard container.

(f) Place the corrugated wraparound around the unit. Insert the two corrugated side pads and the two corrugated end wedges between the unit and the wraparound.

(g) Insert the four corner wedges to locate the unit rigidly.

(h) Insert the test leads within the side packages. Place the top corrugated pad over the unit and seal the box.

5-2 Identify the container in accordance with the appropriate specification.

PART 6
PARTS LIST

INTRODUCTION

6-1 This Parts List describes and illustrates the items necessary to support the Electronic Multimeter, Model 1605M, manufactured by the Hickok Electrical Instrument Company, Cleveland, Ohio.

6-2 The purpose of this Parts List is to assist supply, maintenance and overhaul personnel in identifying, requisitioning, issuing and storing replaceable parts of the equipment.

6-3 Abbreviations used throughout this Parts List are in compliance with Military Standard MIL-STD-12.

GROUP ASSEMBLY PARTS LIST

6-4 The Group Assembly Parts List consists of a breakdown parts list in order of disassembly, separated into figures by assemblies. The parts listed are, in most cases, keyed to associated illustrations by figure and index numbers and are listed in disassembly sequence except where the sequence of disassembly does not apply.

FIGURE AND INDEX NUMBER COLUMNS

6-5 The first two numbers listed in this column of the Group Assembly Parts List represent the figure number of the illustration in which the corresponding part is shown. The third number following the hyphen is the index number used, where applicable, to relate the part in the illustration with the part number and nomenclature in the text. Where an assembly or detail part has not been assigned an index number, only the figure number is shown for the part.

PART NUMBER COLUMN

6-6 The numbers in this column are primarily government standard numbers, Hickok part numbers, or vendor part numbers where available.

VENDOR PART NUMBERS

6-7 Vendor part numbers are used to identify parts manufactured by a contractor other than Hickok Electrical Instrument Company. The vendor part number, when available, appears in the Part Number column. If no vendor number has been assigned, a "No Number" entry appears in the Part Number column of the Group Assembly Parts List and the Hickok specification number is shown at the end of the description. Where there is no vendor part number, the control drawing specification is listed.

NOMENCLATURE COLUMN

6-8 This column contains the complete nomenclature of each item, properly arranged, in accordance with the specification. It is based on Hickok's drawing title, plus any technical data not shown as part of the drawing title which is necessary to completely identify that particular item. The Nomenclature column for commercial parts include the type, model specifications and the name of the design manufacturer. The Nomenclature column for commercial hardware includes such identifying information as size, material and type.

6-9 The identifying noun is the first word of the nomenclature. If the part is an assembly, the word "Assembly" immediately follows the noun. This is followed by a dash (-) and by the descriptive part of the nomenclature.

Abbreviations	Term
alum.	aluminum
comp	composition
cps	cycles per second
c/w	complete with
dia	diameter
dep	deposit
fil	fillister
int	internal
mtg	mounting
Spec Cont No.	Specification Control Number
vac	alternate current volts
vdc	direct current volts
vdcw	direct current working volts

Fig. 6-1 List of Abbreviations

Fig. 6-2

Designation	Manufacturer or Representative	Address
00327	Welwyn International, Inc.	Cleveland, OH
01121	Allen Bradley Co.	Milwaukee, WI
01295	Texas Instrument, Inc.	Dallas, TX
02660	Amphenol Corp.	Broadview, IL
04009	Arrowhart, Inc.	Hartford, CT
04713	Motorola Semiconductor Products, Inc.	Phoenix, AZ
06915	Richco Plastic Co.	Chicago, IL
13919	Burr-Brown Research Corp.	Tucson, AZ
28569	Hickok Electrical Instrument Co.	Cleveland, OH
37942	Mallory, P.R. and Co., Inc.	Indianapolis, IN
56289	Sprague Electric Co.	North Adams, MA
70903	Belden Mfg. Co.	Chicago, IL
71450	CTS Corp.	Elkhart, IN
71590	Centralab, Div. of Globe Union, Inc.	Milwaukee, WI
72512	Harry Davies Molding Co.	Chicago, IL
72982	Erie Technology Products, Inc.	Erie, PA
73445	Amperex Electronic Corp.	Long Island, NY
74016	Manhattan and Bronx Electric Wire and Cable Co.	New York, NY
74970	Johnson, E.F., Co.	Waseca, MN
75915	Littlefuse, Inc.	Des Plaines, IL
76545	Mueller Electric Co.	Cleveland, OH
78189	Shakeproof Div. of Illinois Tool Works	Elgin, IL
82389	Switchcraft, Inc.	Chicago, IL
83330	Herman H. Smith, Inc.	Brooklyn, NY
84048	IRC, Div. of TRW, Inc.	St. Petersburg, FL
86510	Philpott Rubber Co.	Cleveland, OH
86928	Seastrom Mfg. Co., Inc.	Glendale, CA
87930	Tower Mfg. Co.	Providence, RI
91637	Dale Electronics, Inc.	Columbus, NE
No Fed. Stock Code	OPCOA, Inc.	Edison, NJ
No Fed. Stock Code	R-Ohm Corp.	Irvine, CA

Fig. 6-2 List of Manufacturers

6-10 When an item has been assigned a reference designation, that designation appears in parentheses immediately following the descriptive nomenclature. For future assignments ( ) are provided. This is followed by the vendor code, where applicable, in parentheses, followed by the Hickok specification number, also in parentheses.

VENDOR CODES

6-11 Where available from drawing sources, the vendor's identification code appears parenthetically at the end of the part description. If no code has been authorized, the vendor name and address is listed. All codes are in accordance with the Federal Supply Code for Manufacturers, Cataloging Handbook H4-1 and H4-2.

HICKOK SPECIFICATION NUMBERS

6-12 On many items manufactured by contractors other than Hickok Electrical Instrument Company, specification control is retained by Hickok. All required specifications of a part are listed in a single document which is assigned a specification control number. This number is shown within a parenthetical note following the vendor code; for example, (Spec Cont No. 3085-447).

6-13 The number assigned to a part by the manufacturing contractor is the number shown in the Part Number column of the Group Assembly Parts List.

ATTACHING PARTS

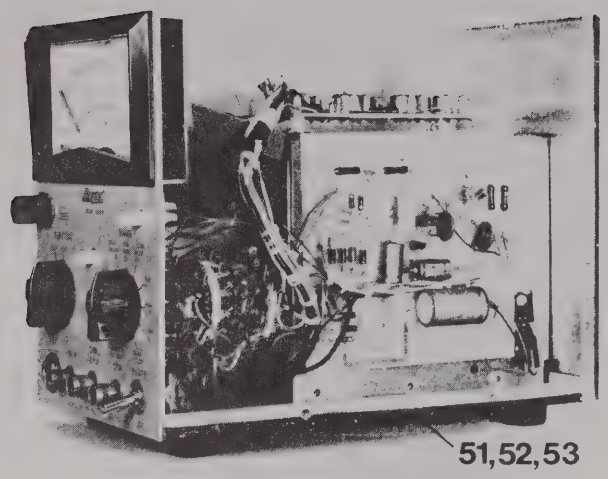
6-14 Attaching parts are listed in the same indent and immediately following the item(s) to be attached. When the item to be attached is an assembly or subassembly the components of that assembly or subassembly are listed between the separating symbol "- - - * - - -" and are indented to show correct relationship to their assembly which appears above the caption "ATTACHING PARTS". The quantity listed in the Units Per Assembly column indicates the quantity required for attaching a single part.

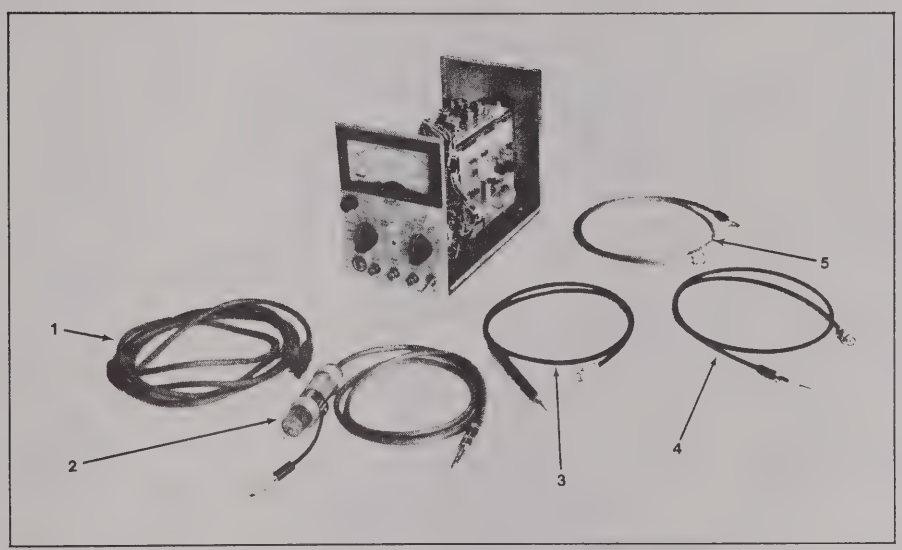
ITEMS NOT LISTED

6-15 Bulk items such as electrical wiring or cabling, vinyl tubing, and sleeving are not listed. Parts which lose their identity by being soldered, brazed, welded, riveted, swaged, cemented, sealed, or otherwise attached to other parts or assemblies in such manner as to be permanent, and not subject to disassembly are not listed in the Parts List.

UNITS PER ASSEMBLY COLUMN

6-16 Listings in this column indicate the quantity of parts required per assembly. Abbreviation AR (as required) indicates that the quantity is determined by the specific requirements of that component.





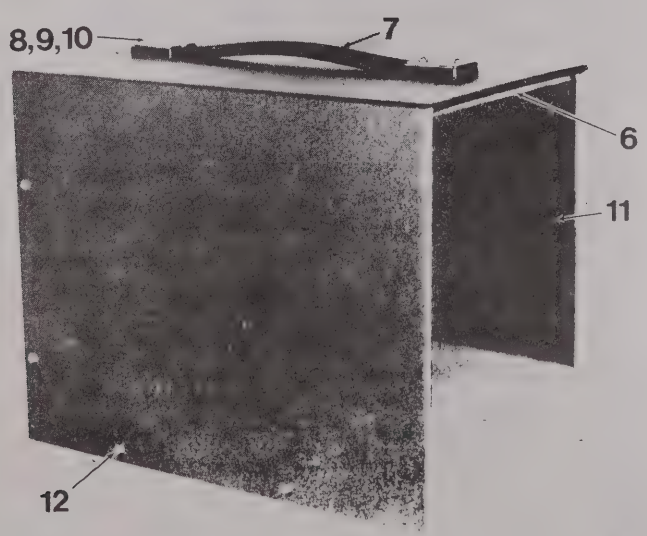


Fig. 6-3 Electronic Multimeter, 1605M (Page 1 of 2)

GROUP ASSEMBLY PARTS LIST

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1605M		
	MAJOR ASSEMBLY	ELECTRONIC MULTIMETER, 1605M		
	PART NUMBER	NOMENCLATURE		
6-3	902-539	Multimeter - Electronic, 1605M (28569)	Ref	
-1	17258	Cord - Line, 8 ft, SVT (70903) (Spec Cont No. 3675-51)	1	
-2	16970-123	Test Lead Assembly - AC Probe (28569) (See Fig. 6-4 for breakdown)	1	
-3	12450-450	Test Lead Assembly - DC Volts (28569) (See Fig. 6-5 for breakdown)	1	
-4	12450-451	Test Lead Assembly - OHMS/DCA (28569) (See Fig. 6-5 for breakdown)	1	
-5	12450-452	Test Lead Assembly - COM (28569) (See Fig. 6-5 for breakdown)	1	
-6	2640-122	Brace - Panel, 0.062 in. alum. (28569)	1	
-7	7820	Handle - Black, 7-1/2 in. lg (77251) (Spec Cont No. 8330-117)	1	
		ATTACHING PARTS		
-8	19096-456	Screw - 4-40 x 3/8 pan hd, cross recessed, steel, cad pl, clear chromate (28569)	4	
-9	23572-112	Washer - Lock, No. 6, split type (28569)	4	
-10	14188-112	Nut - Hexagon, No. 6-32, brass, ni pl (28569)	4	
		- - - * - - -		
-11	3145-733	Cabinet - Painted (28569)	1	
		ATTACHING PARTS		
-12	19085-128	Screw - No. 6 x 1/4 in. lg, type F, pan hd, cross recessed, stainless steel (28569)	9	
		- - - * - - -		
-13	880-032	Meter - K movement, pivot and jewel; Model 88 case; 0.5 ma shunted to 1 ma with copper resistor (M1) (28569)	1	
		ATTACHING PARTS		
-14	19096-656	Screw - Machine, 6-32 x 3/8 pan hd, cross recessed, steel, cad pl, clear chromate (28569)	2	
		- - - * - - -		
-15	2661-424	Bracket - Meter mounting (28569)	2	
-16	19860-429	Support - Front panel (28569)	1	
		ATTACHING PARTS		
-17	14145-45	Nut - Hexagon, No. 6-32, steel, cad pl, clear chromate (28569)	1	
-18	23572-138	Washer - Lock, split, No. 6 (28569)	1	
-19	23578-138	Washer - Flat, No. 6, brass, ni pl (28569)	1	
		- - - * - - -		
-20	16026-942	Panel - Front, assembly (28569) (See Fig. 6-6 for breakdown)	1	
		ATTACHING PARTS		
-21	19085-128	Screw - No. 6 x 1/4 in. lg, type F, pan hd, cross recessed, stainless steel (28569)	3	
		- - - * - - -		

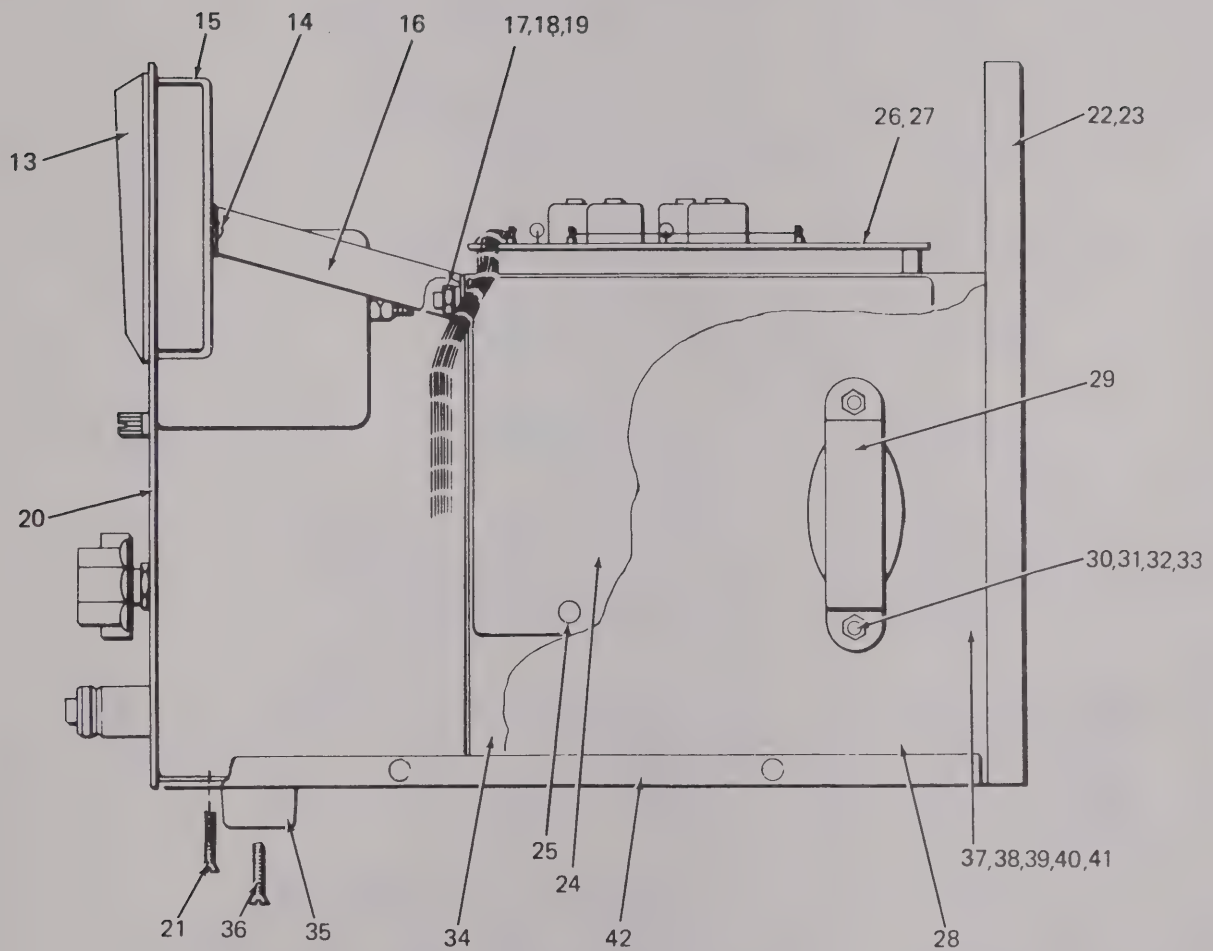


Fig. 6-3 Electronic Multimeter, 1605M (Page 2 of 2)

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY , ELECTRONIC MULTIMETER, 1605M (cont) PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-3-22	16026-943	Panel - Rear, assembly (28569) (See Fig. 6-9 for breakdown)	1	
		ATTACHING PARTS		
-23	19085-128	Screw - No. 6 x 1/4 in. lg, type F, pan hd, cross recessed, stainless steel (28569)	2	
		- - - * - - -		
-24	2421-745	Amplifier Board Assembly (28569) (See Fig. 6-10 for breakdown)	1	
		ATTACHING PARTS		
-25	LCBS-4N	Support - Circuit board (06915) (Spec Cont No. 19860-436)	6	
		- - - * - - -		
-26	2421-746	Calibration Board Assembly (28569) (See Fig. 6-11 for breakdown)	1	
		ATTACHING PARTS		
-27	LCBS-4N	Support - Circuit board (06915) (Spec Cont No. 19860-436)	4	
		- - - * - - -		
-28	3224-507	Chassis Assembly (28569)	1	
-29	20800-492	Transformer - Power (28569)	1	
		ATTACHING PARTS		
-30	19096-856	Screw - 8-32 x 3/8 pan hd, cross recessed, steel, cad pl, clear chromate (28569)	2	
-31	23572-164	Washer - Lock, No. 8, split type (28569)	2	
-32	14146-31	Nut - Hexagon, No. 8-32 (28569)	2	
-33	23578-164	Washer - No. 8, flat, brass, ni pl (28569)	2	
		- - - * - - -		
-34	3225-518	Chassis (28569)	1	
-35	BH-2095-W	Foot - Rubber (86510) (Spec Cont No. 6050-23)	4	
		ATTACHING PARTS		
-36	19085-128	Screw - No. 6 x 1/4, type F, pan hd, cross recessed, stainless steel (28569)	8	
		- - - * - - -		
-37	7806C	Integrated Circuit - 6 volt, 1 amp, voltage regulator (Z3) (04713) (Spec Cont No. 9800-193)	1	
		ATTACHING PARTS		
-38	14143-17	Nut - Hex, 4-40 steel, cad pl, clear chromate (28569)	1	
-39	19096-460	Screw - 4-40 x 5/8, pan hd, cross recessed, steel, cad pl, clear chromate (28569)	1	
-40	23574-112	Washer - Lock, No. 6, split type (28569)	1	
-41	5607-45	Washer - Nylon, shoulder (86928) (Spec Cont No. 23480-104)	1	
		- - - * - - -		
-42	3145-766	Cabinet - Bottom panel, painted (28569)	1	

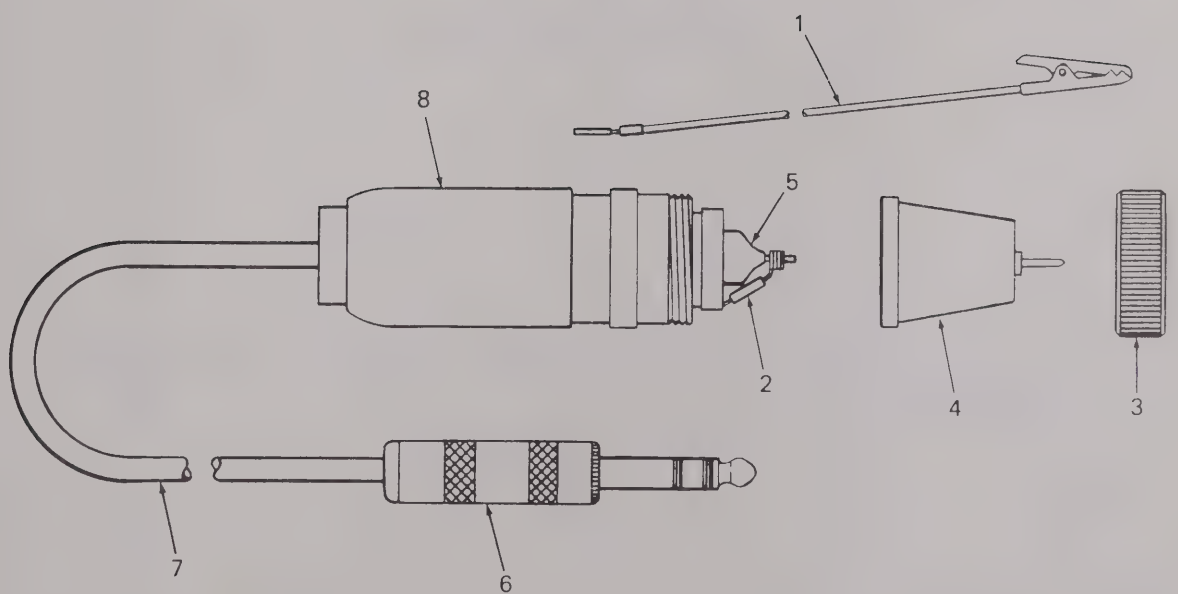
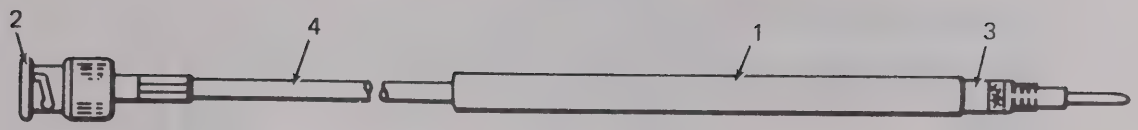
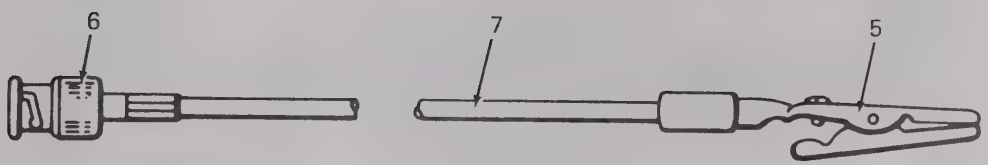


Fig. 6-4 Test Lead Assembly - AC Probe

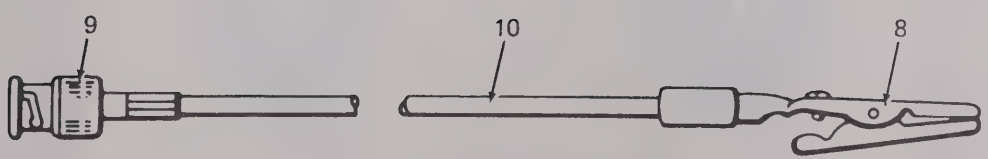
FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1605M		
	MAJOR ASSEMBLY	AC PROBE LEAD ASSEMBLY		
	PART NUMBER	NOMENCLATURE		
6-4	16970-123	Test Lead Assembly - AC Probe (28569) (See Fig. 6-3, item 2 for NHA)	Ref	
-1	12450-483	Ground Lead Subassembly (28569)	1	
-2	CB3065	Resistor - Fixed, carbon comp, 30 megohms, ±5%, 1/4 watt (R2) (01121) (Spec Cont No. 18456-301)	1	
-3	18825-123	Coupling (28569)	1	
-4	16976-52	Nose - Probe (28569)	1	
-5	EA-52	Tube - UHF (73445) (Spec Cont No. 20875-161)	1	
-6	297	Plug (82389) (Spec Cont No. 16525-270)	1	
-7	3025-898	Cable - 4 ft. (28569)	1	
-8	8900-105	Housing - Probe (28569)	1	



LEAD ASSEMBLY 12450-450



LEAD ASSEMBLY 12450-451



LEAD ASSEMBLY 12450-452

Fig. 6-5 Test Lead Assemblies

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY TEST LEAD ASSEMBLIES PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-5	12450-450	Test Lead Assembly - DC Volts (28569) (See Fig. 6-3, item 3 for NHA)	Ref	
-1	302	Test Prod - Insulated, 4 in. red handle, c/w prod tip (83330) (Spec Cont No. 16975-1)	1	
-2	36775	Plug - BNC, quick-crimp type (02660) (Spec Cont Co. 16525-269)	1	
-3	EB1055	Resistor - Fixed, comp, 1 megohm ±5%, 0.5 watt (01121) (Spec Cont No. 18415-101)	1	
-4	3025-272	Cable - Coaxial RG58A/U, 3 ft. 6 in. long (28569)	1	
	12450-451	Test Lead Assembly - OHMS/DCA (28569) (See Fig. 6-3, item 4 for NHA)	Ref	
-5	60H	Clip - Alligator, insulated handle, red (76545) (Spec Cont No. 3300-9)	1	
-6	36775	Plug - BNC, quick-crimp type (02660) (Spec Cont No. 16525-269)	1	
-7	M3611	Cable - Shielded, 3 ft. 6 in. long (74016) (Spec Cont No. 3025-899)	1	
	12450-452	Test Lead Assembly - COM (28569) (See Fig. 6-3, item 5 for NHA)	Ref	
-8	60H	Clip - Alligator, insulated handle, black (76545) (Spec Cont No. 3300-10)	1	
-9	36775	Plug - BNC, quick-crimp type (02660) (Spec Cont No. 16525-269)	1	
-10	M3611	Cable - Shielded, 3 ft. 6 in. long (74016) (Spec Cont No. 3025-899)	1	

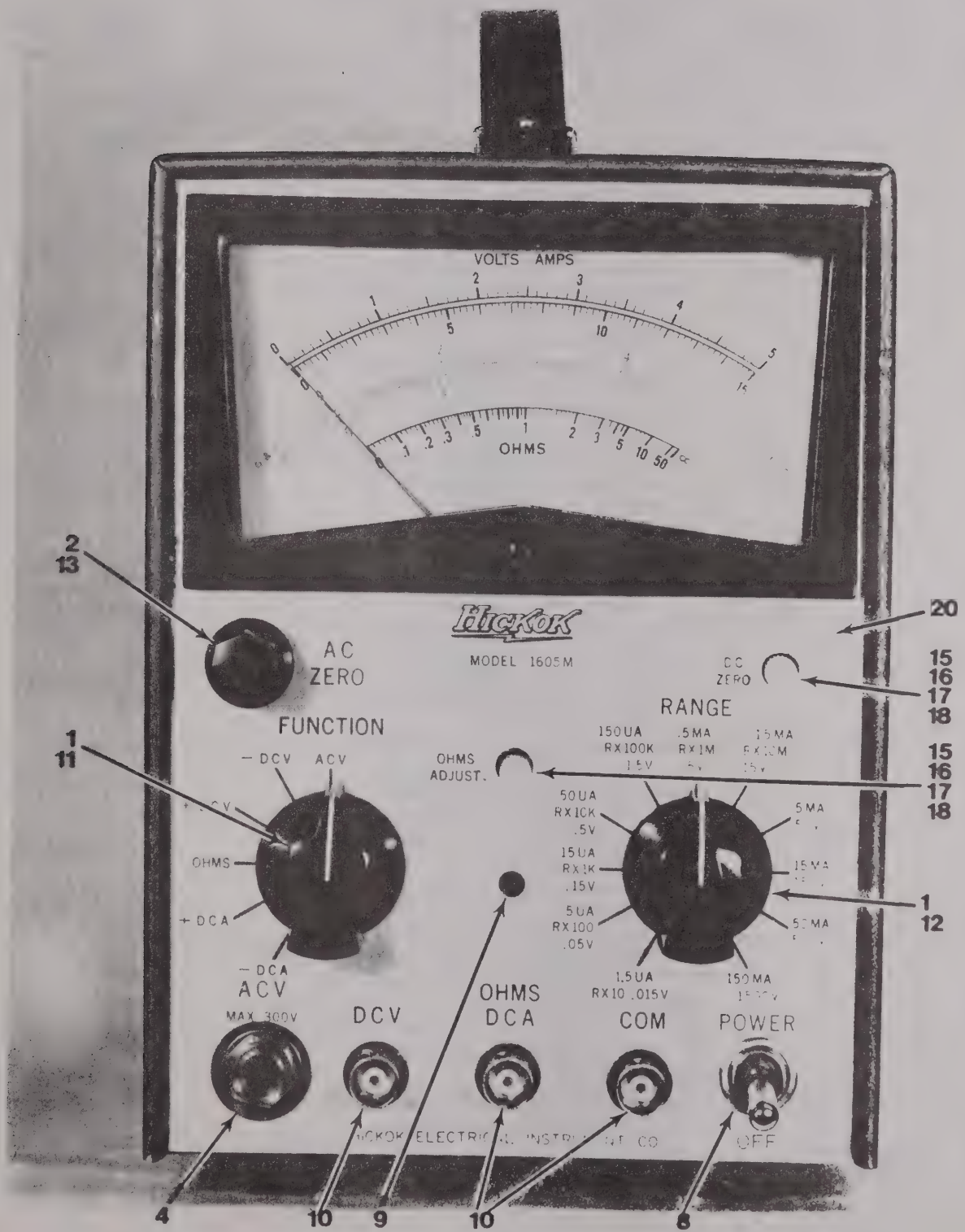


Fig. 6-6 Front Panel Assembly (Page 1 of 2)

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY FRONT PANEL ASSEMBLY PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-6	16026-942	Front Panel Assembly (28569) (See Fig. 6-3, item 20 for NHA)	Ref	
-1	1919E	Knob - FUNCTION and RANGE switches (72512) (Spec Cont No. 11505-154)	2	
-2	1900	Knob - AC ZERO (72512) (Spec Cont No. 11505-290)	1	
-3	Type 858	Capacitor - Fixed, ceramic disc, 3300 μf ±10%, 1000 vdcw (C4) (72982) (Spec Cont No. 3110-317)	1	
-4	No. 12B	Jack - 3 conductor, 'Litteljax' (J4) (82389) (Spec Cont No. 10300-80)	1	
-5	2440-20-00	Lug - Terminal (78189) (Spec Cont No. 12991-210)	1	
-6	5604-68	Washer - Shoulder, fibre, 3/4 od x 3/8 id x 1/32 in. shoulder, 1/2 in. flange (86928) (Spec Cont No. 23190-36)	1	
-7	5602-133-062	Washer - Flat, fibre, 5/8 od x 3/8 id x 1/16 in. thk (86928) (Spec Cont No. 23190-35)	1	
-8	20994-LH	Switch - POWER, Toggle, SPST (S1) (04009) (Spec Cont No. 19911-71)	1	
-9	LSL-3L	Lamp - LED, (DS1) OPCOA Inc. (Spec Cont No. 12270-129)	1	
-10	31-221	Receptacle - BNC, Bulkhead, COM, OHMS/DCA, DCV (J1, J2, J3) (02660) (Spec Cont No. 3475-78)	1	
-11	19915-777	Switch Assembly - FUNCTION (28569) (See Fig. 6-7 for breakdown)	1	
-12	19915-776	Switch Assembly - RANGE (28569) (See Fig. 6-8 for breakdown)	1	
-13	Type AW	Potentiometer - Wire wound, AC ZERO, 10K ohms, ±10% linear, 3-5 watt, c/w mtg hardware (R28) (71450) (Spec Cont No. 16925-758)	1	
-14	Type 117	Potentiometer - Wire wound, 1K ohm, ±10% linear, 2-3 watts, OHMS ADJUST (R26) (71450) (Spec Cont No. 16925-759)	1	
-15	Type 117	Potentiometer - Wire wound, 10K ohms, ±10% linear, 2-3 watts, DC ZERO (R34) (71450) (Spec Cont No. 16925-913)	1	
		ATTACHING PARTS		
-16	19098-404	Screw - Machine, flat head, No. 4-40, cross recessed 1/4 in. lg brass, ni pl (28569)	4	
-17	23572-112	Washer - Lock, split, No. 4, phos brz, ni pl (28569)	4	
-18	14143-17	Nut - Hexagon, No. 4-40, steel, cad pl, clear chromate (28569)	4	
		- - - * - - -		
-19	2661-423	Bracket - Potentiometer holder, 0.062 in. thk alum. (28569)	1	
-20	16024-509	Panel - Front, 0.062 in. alum., machined and lithographed (28569)	1	

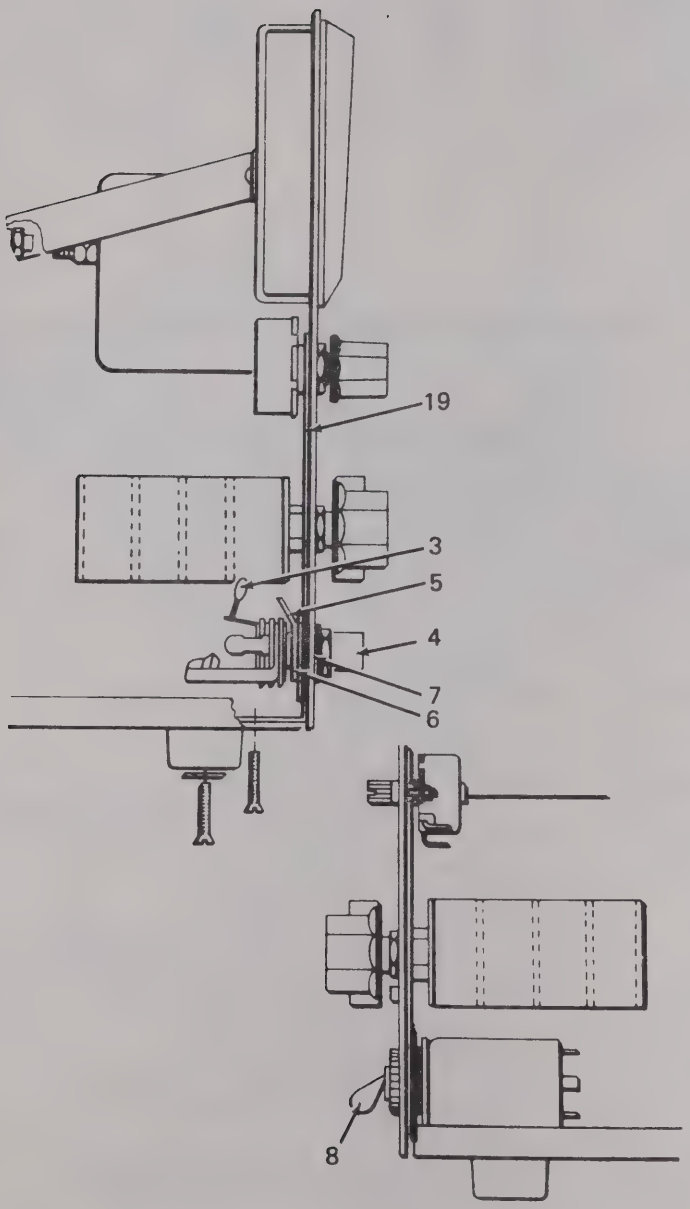


Fig. 6-6 Front Panel Assembly (Page 2 of 2)

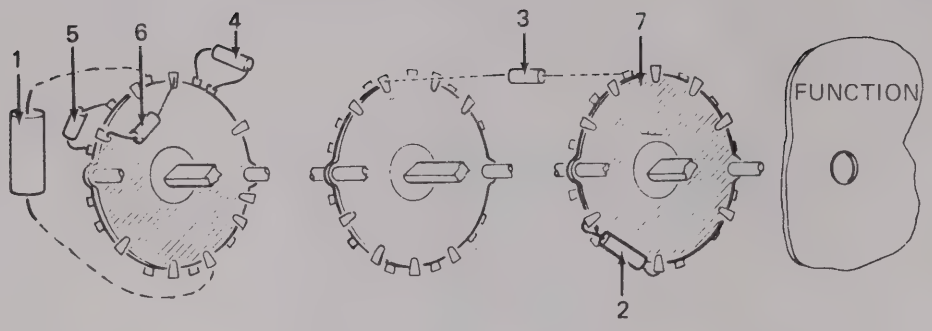


Fig. 6-7 FUNCTION Switch Assembly, Part No. 19915-777

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY FUNCTION SWITCH ASSEMBLY PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-7	19915-777	Switch Assembly - FUNCTION (28569) (See Fig. 6-6, item 11 for NHA)	Ref	
-1	Type CGH-2	Resistor - Fixed, metal film, 60 megohms, ±5%, 2 watts (R29) (84048) (Spec Cont No. 18575-767)	1	
-2	Type MFF-1/2	Resistor - Fixed, metal film, 158 ohms, ±1%, 1/2 watt (R49) (91637) (Spec Cont No. 18526-170)	1	
-3	Type MFF-1/4	Resistor - Fixed, metal film, 115 ohms, ±1%, 0.25 watt (R45) (91637) (Spec Cont No. 18555-251	1	
-4	GB1005	Resistor - Fixed, carbon comp, 10 ohms, ±5%, 1 watt (R4) (01121) (Spec Cont No. 18420-101)	1	
-5	Type R25	Resistor - Fixed, deposited carbon, 1M, ±5% 1/4 watt (R5) (R-Ohm Corp.) (Spec Cont No. 18470-105)	1	
-6	Type MFF-1/2	Resistor - Fixed, metal film, 100K ohms, ±1%, 0.5 watt (R27) (91637) (Spec Cont No. 18525-897)	1	
-7	19912-675	Switch - Rotary, ceramic, 3 section, 6 position FUNCTION (S3) (28569) (Spec Cont No. 19912-675)	1	

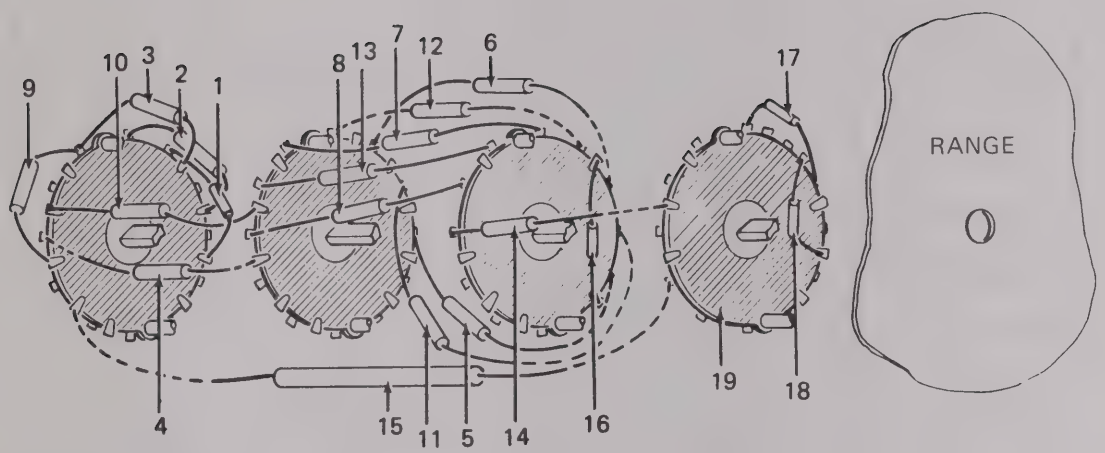


Fig. 6-8 RANGE Switch Assembly, Part No. 19915-776

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1605M		
	MAJOR ASSEMBLY	RANGE SWITCH ASSEMBLY		
	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE		
6-8	19915-776	Switch Assembly - RANGE (28569) (See Fig. 6-6, item12 for NHA)	Ref	
-1	Type RS-1A	Resistor - Fixed, wire wound, 2 ohms, ±0.5%, 1 watt (R20) (91637) (Spec Cont No. 18575-768)	1	
-2	RS-2	Resistor - Fixed, wire wound, 7 ohms, ±0.5%, 2 watt (R19) (91637) (Spec Cont No. 18575-769)	1	
-3	Type MFF-1/2	Resistor - Fixed, metal film, 20 ohms, ±0.5%, 0.5 watt (R18) (91637) (Spec Cont No. 18526-117)	1	
-4	Type MFF-1/2	Resistor - Fixed, metal film, 200 ohms, ±0.5%, 0.5 watt (R16) (91637) (Spec Cont No. 18526-159)	1	
-5	Type MFF-1/2	Resistor - Fixed, metal film, 2K ohms, ±0.5%, 0.5 watt (R14) (91637) (Spec Cont No. 18526-62)	1	
-6	Type MFF-1/2	Resistor - Fixed, metal film, 20K ohms, ±0.5%, 0.5 watt (R12) (91637) (Spec Cont No. 18526-160)	1	
-7	Type MFF-1/2	Resistor - Fixed, metal film, 200K ohms, ±0.5%, 0.5 watt (R10) (91637) (Spec Cont No. 18526-161)	1	
-8	Type MFF-1/2	Resistor - Fixed, metal film, 2 megohms ±0.5%, 0.5 watt (R8) (91637) (Spec Cont No. 18526-162)	1	
-9	Type MFF-1/2	Resistor - Fixed, metal film, 70 ohms, ±0.5%, 0.5 watt (R17) (91637) (Spec Cont No. 18526-163)	1	
-10	Type MFF-1/2	Resistor - Fixed, metal film, 700 ohms, ±0.5%, 0.5 watt (R15) (91637) (Spec Cont No. 18526-164)	1	
-11	Type MFF-1/2	Resistor - Fixed, metal film, 7K ohms, ±0.5%, 0.5 watt (R13) (91637) (Spec Cont No. 18526-165)	1	
-12	Type MFF-1/2	Resistor - Fixed, metal film, 70K ohms, ±0.5%, 0.5 watt (R11) (91637) (Spec Cont No. 18526-166)	1	
-13	Type MFF-1/2	Resistor - Fixed, metal film, 700K ohms, ±0.5%, 0.5 watt (R9) (91637) (Spec Cont No. 18526-167)	1	
-14	Type M12	Resistor - Fixed, metal film, 6 megohms, ±0.5%, 0.5 watt (R7) (00327) (Spec Cont No. 18526-128)	1	
-15	Type M14D	Resistor - Fixed, metal film, 89 megohms, ±1%, 2 watt (R6) (91637) (Spec Cont No. 18575-611)	1	
-16	Type MFF—1/2	Resistor - Fixed, metal film, 1 megohm, ±1%, 0.5 watt (R24) (36002) (Spec Cont No. 18525-888)	1	
-17	Type MFF-1/4	Resistor - Fixed, metal film, 33 ohms, ±1%, 0.25 watt (R43) (91637) (Spec Cont No. 18555-250)	1	
-18	Type MFF-1/4	Resistor - Fixed, metal film, 3.09K ohms, ±1%, 0.25 watt (R25) (91637) (Spec Cont No. 18555-170)	1	
-19	19912-676	Switch - Rotary, ceramic, 4 section, 11 position RANGE (S4) (28569) (Spec Cont No. 19912-676)	1	

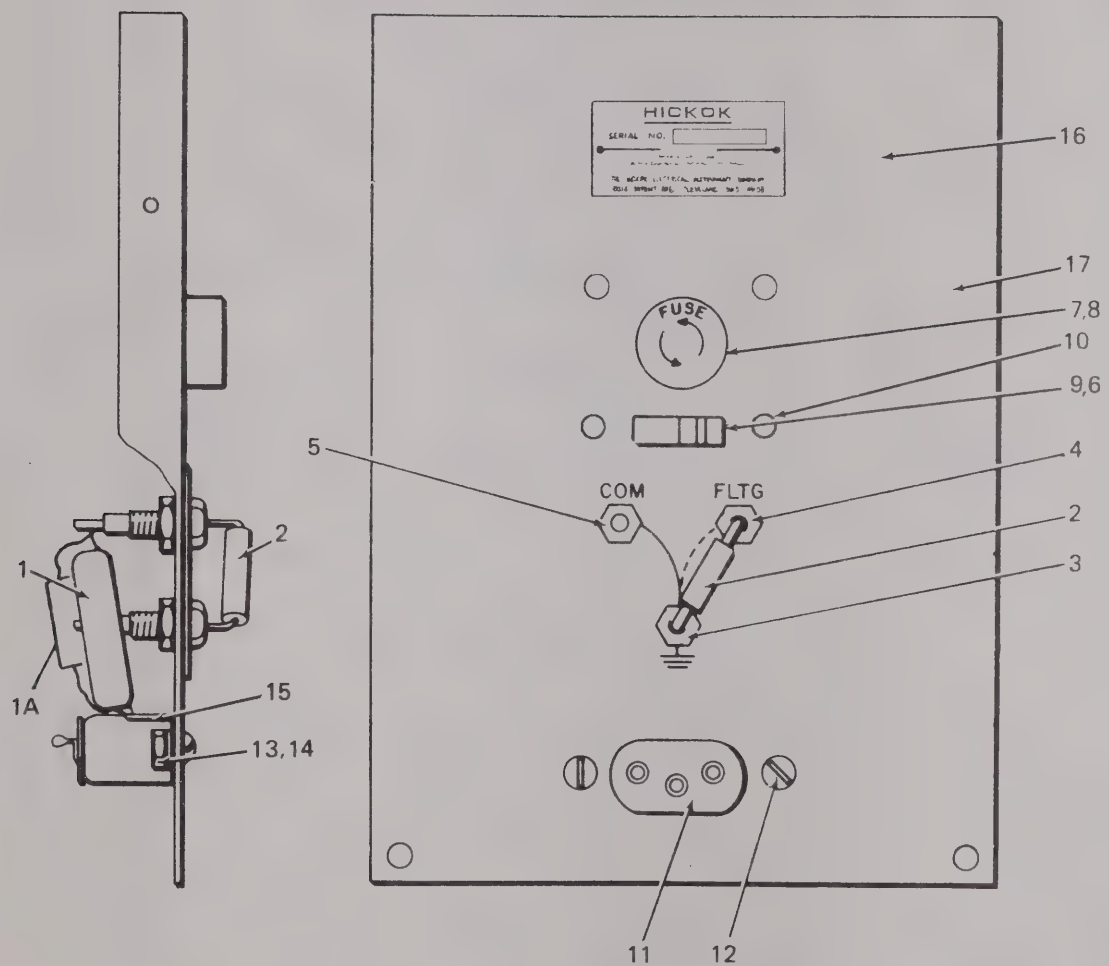


Fig. 6-9 Rear Panel Assembly

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1605M		
	MAJOR ASSEMBLY	REAR PANEL ASSEMBLY		
	PART NUMBER	NOMENCLATURE		
6-9	16026-943	Rear Panel Assembly (28569) (See Fig. 6-3, item 22 for NHA)	Ref	
-1	PVC401	Capacitor - Fixed, mylar, 0.1 μf, 400 vdcw (C9) (37942) (Spec Cont No. 3090-99)	1	
-1A	EB1061	Resistor - Fixed, carbon comp, 10M ohms, ±10%, 0.5 watt (R50) (01121) (Spec Cont No. 18416-102)	1	
-2	16525-272	Plug - Grounding, c/w insulated handle (28569)	1	
-3	105-801	Jack - Pin, white, c/w mtg hardware (74970) (Spec Cont No. 10300-107)	1	
-4	105-802	Jack - Pin, red, c/w mtg hardware (74970) (Spec Cont No. 10300-62)	1	
-5	105-803	Jack - Pin, black, c/w mtg hardware (74970) (Spec Cont No. 10300-64)	1	
-6	19370-470	Spacer (28569)	2	
-7	313-250	Fuse - 0.25A, 3AG SLO-BLO (F1) (75915) (Spec Cont No. 6900-7)	1	
-8	342001	Fuseholder - (75915) (Spec Cont No. 8825-49)	1	
-9	46256LFR	Switch - Slide, DPDT (S2) (82389) (Spec Cont No. 19911-117)	1	
		ATTACHING PARTS		
-10	19046-190	Screw - 4-40 x 1/2 binding hd, steel, ni pl (28569)	2	
		- - - * - - -		
-11	UH1061-1	Connector - Receptacle, electrical, recessed, input power, three conductor (87930) (Spec Cont No. 3475-297)	2	
		ATTACHING PARTS		
-12	19096-656	Screw - Machine, pan hd, 6-32, 3/8 in. lg, steel, cad pl, clear chromate (28569)	1	
-13	23574-138	Washer - Lock, int, No. 6, steel, cad pl, chromate bright dip (28569)	1	
-14	14145-45	Nut - Hexagon, No. 6-32, steel, ni pl (28569)	2	
		- - - * - - -		
-15	2102-14-00	Lug - Terminal, 1/4 in. (78189) (Spec Cont No. 12991-209)	1	
-16	14100-763	Nameplate - (28569)	1	
-17	16025-464	Panel - Rear, (28569)	1	

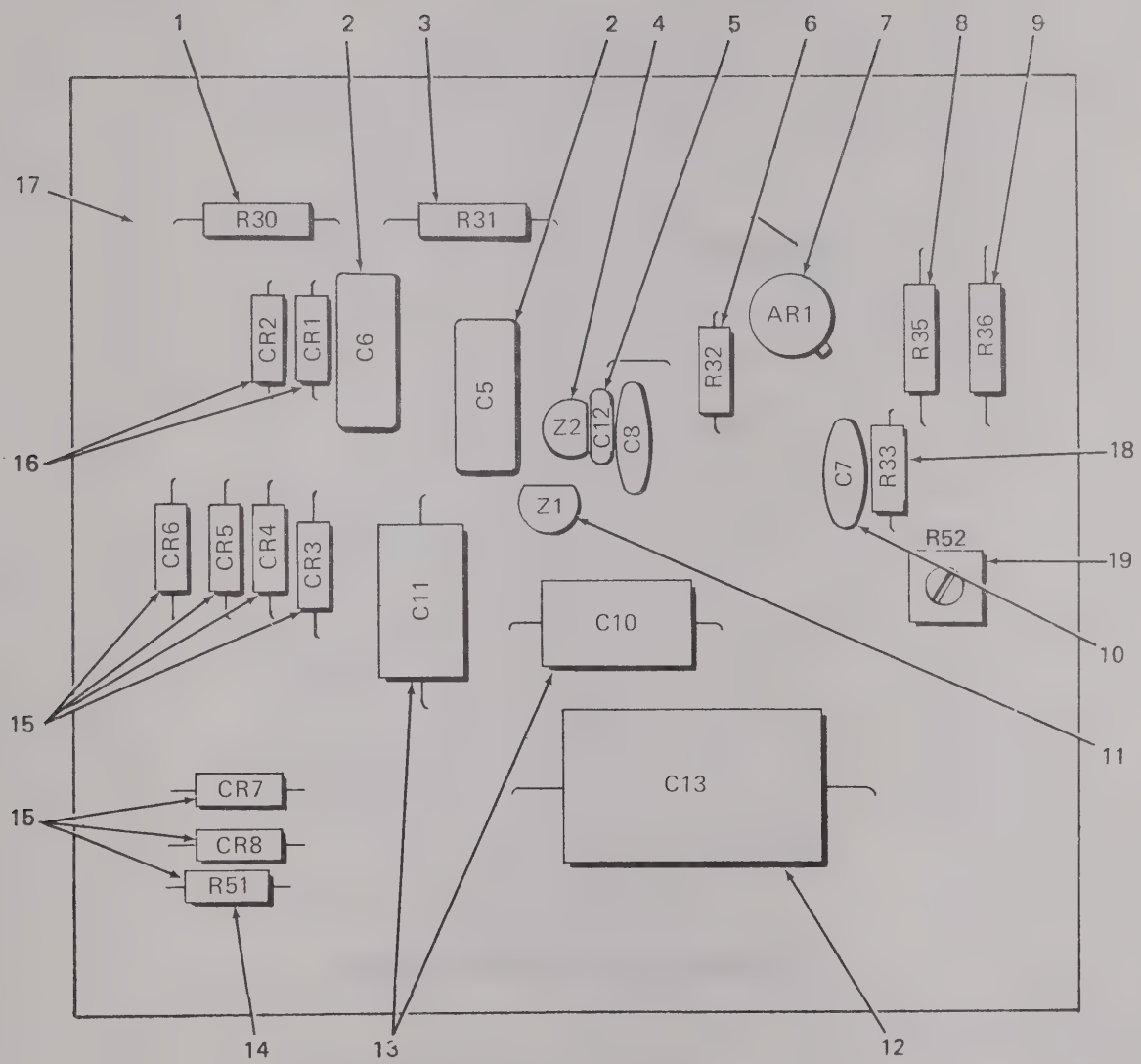


Fig. 6-10 Amplifier Board Assembly, Part No. 2421-745

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY AMPLIFIER BOARD ASSEMBLY PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-10	2421-745	Amplifier Board Assembly (28569) (See Fig. 6-3, item 24 for NHA)	Ref	
-1	Type MFF-1/4	Resistor - Fixed, metal film, 681K ohms, ±1%, 0.25 watt (R30) (91637) (Spec Cont No. 18554-82)	1	
-2	C280MAE/A100K	Capacitor - Fixed, mylar, .1 μf, 250 volts (C5, C6) (73445) (Spec Cont No. 3090-103)	2	
-3	Type MFF-1/2	Resistor - Fixed, metal film, 2.2 megohms, ±1%, 0.5 watt (R31) (91637) (Spec Cont No. 18526-169)	1	
-4	79L15AC	Integrated Circuit, -15 volts, 100 ma, voltage regulator (Z2) (04713) (Spec Cont No. 9800-194)	1	
-5	196D106X 0025KE3	Capacitor - Fixed, tantalum, 10 μf, 20%, 25 volts (C12) (56289) (Spec Cont No. 3085-467)	1	
-6	Type R25	Resistor - Fixed, deposited carbon, 510 ohms, ±5%, 0.25 watt (R32) (R-Ohm Corp) (Spec Cont No. 16925-511)	1	
-7	AD545KH	Integrated Circuit - FET Op, Amp (AR1) (13919) (Spec Cont No. 9800-195)	1	
-8	Type MFF-1/4	Resistor - Fixed, metal film, 100 ohms, ±1%, 0.25 watt (R35) (91637) (Spec Cont No. 18555-249)	1	
-9	Type MFF-1/4	Resistor - Fixed, metal film, 649 ohms, ±1%, 0.25 watt (R36) (91637) (Spec Cont No. 18555-246)	1	
-10	156UK25-104	Capacitor - Fixed, ceramic disc, .1 μf, 25 volts, (C7, C8) (71590) (Spec Cont No. 3110-333)	2	
-11	78L15AC	Integrated Circuit - 15 volts, 100 ma, voltage regulator (Z1) (04713) (Spec Cont No. 9800-176)	1	
-12	ET152X 016A03	Capacitor - Fixed, electrolytic, 1500 μf, 16 volts (C13) (73445) (Spec Cont No. 3085-447)	1	
-13	ET101X 040A6	Capacitor - Fixed, alum electrolytic, 100 μf, 40 volts (C10, C11) (73445) (Spec Cont No. 3085-552)	2	
-14	Type R25	Resistor - Fixed, deposited carbon, 820 ohms, ±5%, 0.25 watt (R51) (R-Ohm Corp) (Spec Cont No. 18470-821)	1	
-15	1N4001	Diode - (CR3, CR4, CR5, CR6, CR7, CR8) (01295) (Spec Cont No. 3870-229)	6	
-16	1N914	Diode - (CR1, CR2) (01295) (Spec Cont No. 3870-175)	2	
-17	2421-744	Board - Amplifier	1	
-18	Type R25	Resistor - Fixed, deposited carbon, 100 ohms, ±5%, 0.25 watt (R33) (R-Ohm Corp) (Spec Cont No. 18470-101)	1	
-19	Type 72PM	Resistor - Variable, 1K ohms, cermet (R52) (Beckman) (Spec Cont No. 16925-810)	1	

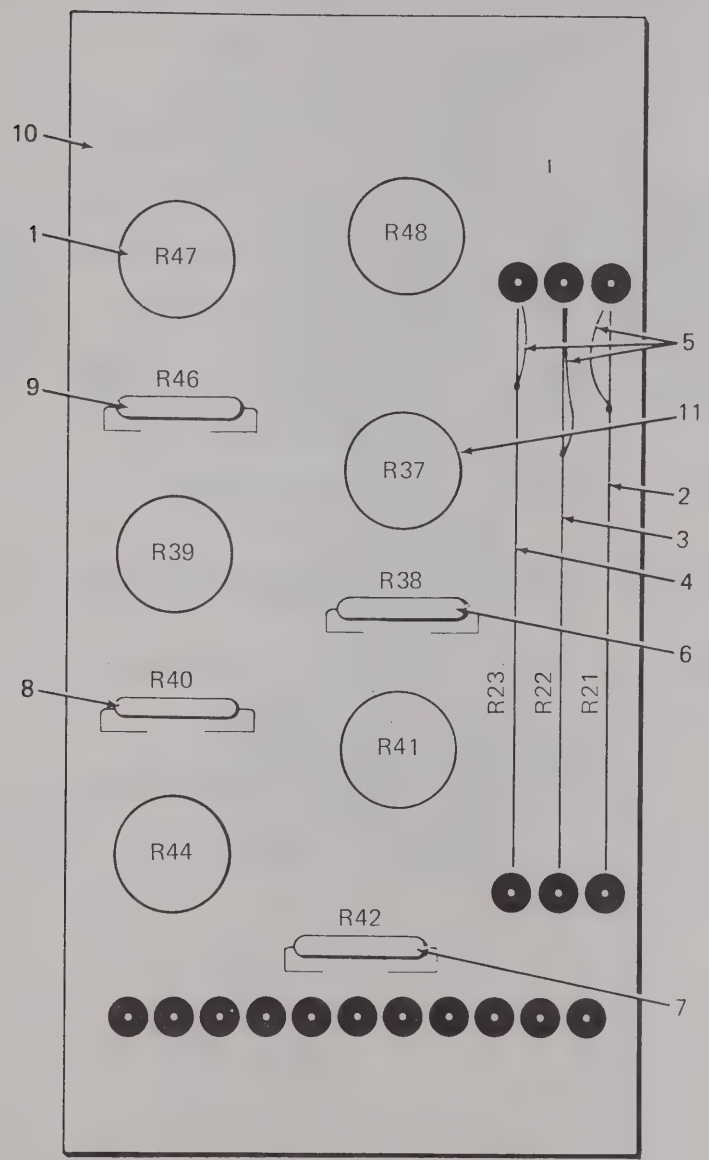


Fig. 6-11 Calibration Board Assembly, Part No. 2421-746

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY CALIBRATION BOARD ASSEMBLY PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-11	2421-746	Calibration Board Assembly (28569) (See Fig. 6-3, item 26 for NHA)	Ref	
-1	115-PC	Potentiometer - Wire wound, 300 ohms, 3 watt (R47, R48, R39, R41, R44) (71450) (Spec Cont No. 16925-757)	5	
-2	18577-257	Wire - Resistance, Manganin No. 32, 0.7 ohm, 3 in. lg (R21) (28569)	1	
-3	18577-258	Wire - Resistance, Manganin No. 26, 0.2 ohm, 3 in. lg (R22) (28569)	1	
-4	18577-259	Wire - Resistance, Manganin No. 22, 0.1 ohm, 3 in. lg (R23) (28569)	1	
-5	23900-53	Wire - Copper, No. 24, tinned, 1 in. lg (28569)	AR	
-6	Type MFF-1/4	Resistor - Fixed, metal film, 300 ohms, ±1%, 0.25 watt (R38) (91637) (Spec Cont No. 18555-232)	1	
-7	Type MFF-1/4	Resistor - Fixed, metal film, 120 ohms, ±1%, 0.25 watt (R42) (91637) (Spec Cont No. 18555-247)	1	
-8	Type MFF-1/4	Resistor - Fixed, metal film, 180 ohms, ±1%, 0.25 watt (R40) (91637) (Spec Cont No. 18555-248)	1	
-9	Type MFF-1/4	Resistor - Fixed, metal film, 10 ohms, ±1%, 0.25 watt (R46) (91637) (Spec Cont No. 18555-138)	1	
-10	2421-591	Printed Circuit Board (28569)	1	
-11	115-PC	Potentiometer - Wire wound, 500 ohms, 3 watt (R37) (71450) (Spec Cont No. 16925-943)		

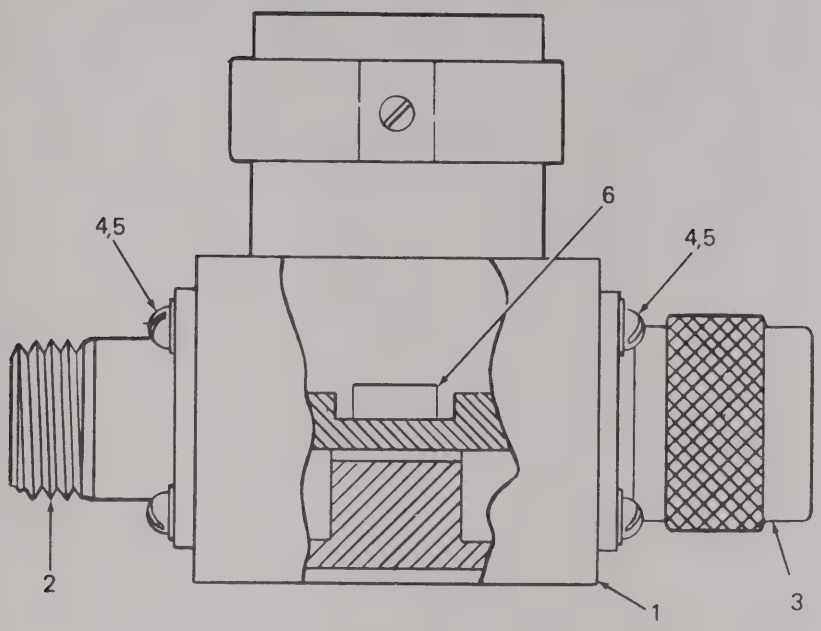


Fig. 6-12 UHF Probe "T" Connector Assembly, Part No. 3475-397

FIGURE AND INDEX NUMBER	GROUP ELECTRONIC MULTIMETER, 1605M MAJOR ASSEMBLY "T" CONNECTOR ASSEMBLY PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASSY	USAGE ON CODE
6-12	3475-397	"T" Connector Assembly - UHF Probe	1	
-1	2400-52	Block Assembly	1	
-2	3475-100	Connector	1	
-3	3475-296	Connector	1	
-4	19096-456	Screw - 4-40 x 3/8	8	
-5	23572-112	Washer - Lock, No. 4	8	
-6	3095-307	Capacitor	1	

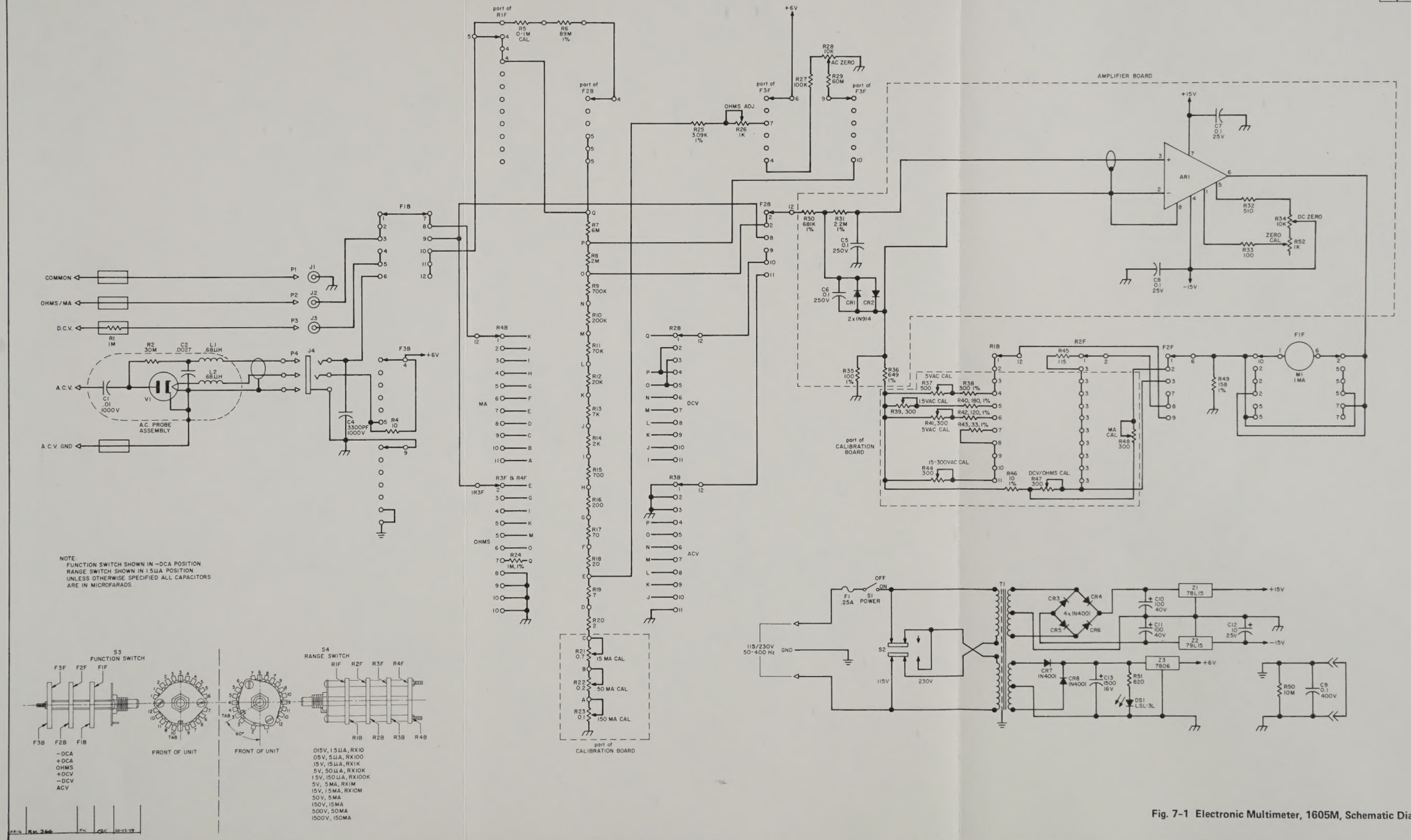


Fig. 7-1 Electronic Multimeter, 1605M, Schematic Diagram